NASA CR-54387

ELECTRICAL INSULATION MATERIALS

SNAP 8 RADIATION EFFECTS TEST PROGRAM

VOLUME II

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FOREWORD

This report and the results described herein (originally issued as Georgia Nuclear Report ER 7644) cover irradiation of selected insulation materials at the Radiation Effects Reactor, Georgia Nuclear Laboratories, Dawsonville, Georgia.

This work was done under subcontract for the Aerojet General Corporation (NASA Contract No. NAS 5-417) in support of the SNAP 8 Radiation Effects on Materials and Components Program. The contract and subcontract were under the technical management of H. O. Slone and A. W. Nice, respectively, of the NASA Lewis Research Center.

TABLE OF CONTENTS

TEST PERFORMANCE SUMMARY

The tests herein reported were performed in accordance with the Experimental Design Manual, ND-5001, revised 27 April 1964. A summary of events is presented here to familiarize the reader with the test history. Detailed procedures and methods may be found in the Experimental Design Manual.

All materials and test specimens were selected by, and received from, the Aerojet-General Corporation. There were in general four types of specimens. These were sheet insulation, wire, fluids and statorettes. For the purpose of testing, these were divided into three catagories; as received, temperature control, and irradiation test. All specimens were conditioned as specified in the design manual and the irradiated and temperature control specimens sealed in metal capsules.

The temperature chambers used were, a Blue M for the temperature control runs and a chamber constructed at GNL, as illustrated in the design manual, for the irradiation test. The method of mounting specimens in the oven is shown in Figure 1 for the irradiation chamber and in Figure 2 for the control specimens.

The wire and sheet insulation materials were placed in capsules as shown in Figure 1 prior to testing. The leak checks, after sealing, were accomplished with a helium detector. This was facilitated because of the small amount of helium mixed with the nitrogen during the filling process.

The fluid containers may be seen in Figure 1. They were equipped with pressure transducers for RER safety considerations and were not part of the performance instrumentation.

A great deal of difficulty was experienced with canning the statorettes because

of the feed-throughs. The standard welding techniques used on the ceramic feed-throughs destroyed the seal on the feed-through between the skirt and the ceramic, causing leaks. A few welded terminals were successful but the failure rate was high. A new technique was worked out to permit welding the terminals with a practically zero failure rate. This process entailed placing the terminal in a metal tube whose outside diameter was equal to the diameter of the feed-through skirt. A second tube was placed over the top of the terminal in such a manner to form a sandwich at the skirt. The welding process bonded together the two tubes and the skirt into a common bond. The top tube was then cut away just above the weld. The result of this technique can be seen in Figure 3. This method was successful because the tubes acted as heat sinks to keep the bond between the skirt and the ceramic cool.

The irradiation and temperature control exposures of the statorettes were not run simultaneously because of the difficulties encountered with feed-throughs and the economics involved. The control test was run after the irradiation test had been completed.

The sequence of events in the test is summarized in the following paragraphs.

Specimens were received from the Aerojet-General Corporation and inspected by the GNL QA Department. They were released to the test group and underwent the conditioning involved prior and during encapsulation as specified in the Experimental Design Manual. When all specimens had been prepared and encapsulated they were mounted in the oven on the test car where they were moved to the Radiation Effects Reactor. The chamber was brought to temperature and the LiH shield shown in Figure 4 was lowered and placed between the reactor and the test specimens. The nuclear environment was thus modified to achieve the experimental design manual requirements. The reactor was operated at 3 MW for

136 hours of operating time, to give approximately 10^8 Rads gamma and 4×10^{13} nvt to the specimens. The operational profile is shown in Section 13 of this report.

During the irradiation period the statorette characteristics were measured and the fluid pressure transducers monitored to see that no pressure buildup occurred. All other specimens were statically irradiated.

The temperature table for the test is shown in Table 1 and the locations are shown in Figure 1.

The Blue M oven containing the control specimens except statorettes, was set at $392^\circ \pm 3^\circ$ F where it remained for the duration of the test. The statorettes control test was conducted at $386 \pm 3^\circ$ F to agree with the temperature of the statorette iron during the irradiation.

When the irradiation had been completed the reactor was shut down but left in position. The residual gamma activity from the core was sufficiently high to give the required rates for the statorette breakdown voltage test. Upon completing the breakdown test, the chamber was allowed to cool and returned to the Radiation Effects Laboratory where post-irradiation testing was accomplished.

Details of the environmental test results are found in succeeding sections of this report.

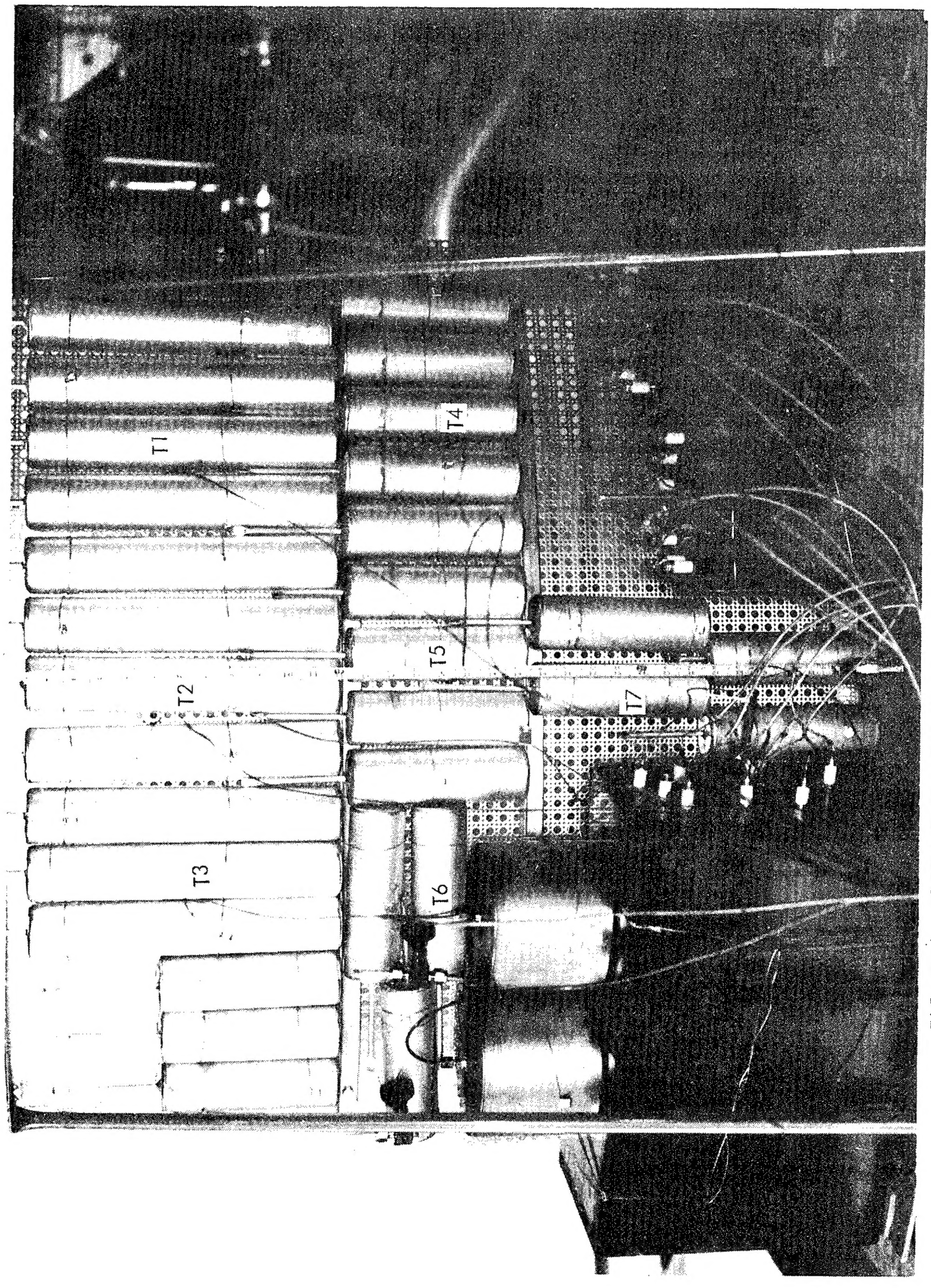


FIGURE 1 SPECIMENS MOUNTED IN CHAMBER FOR IRRADIATION TEST

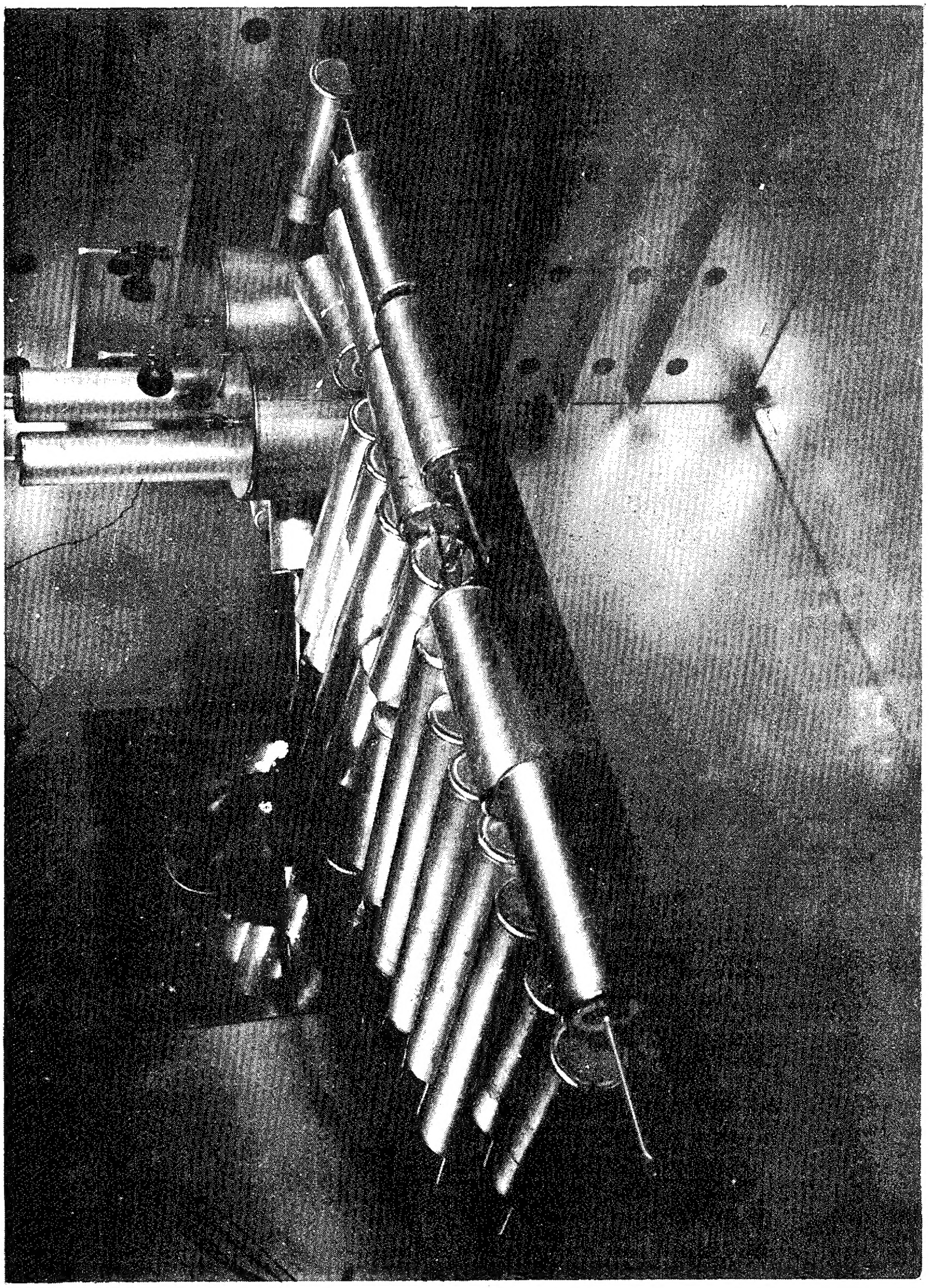


FIGURE 2 SPECIMENS IN CHAMBER FOR TEMPERATURE CONTROL TEST

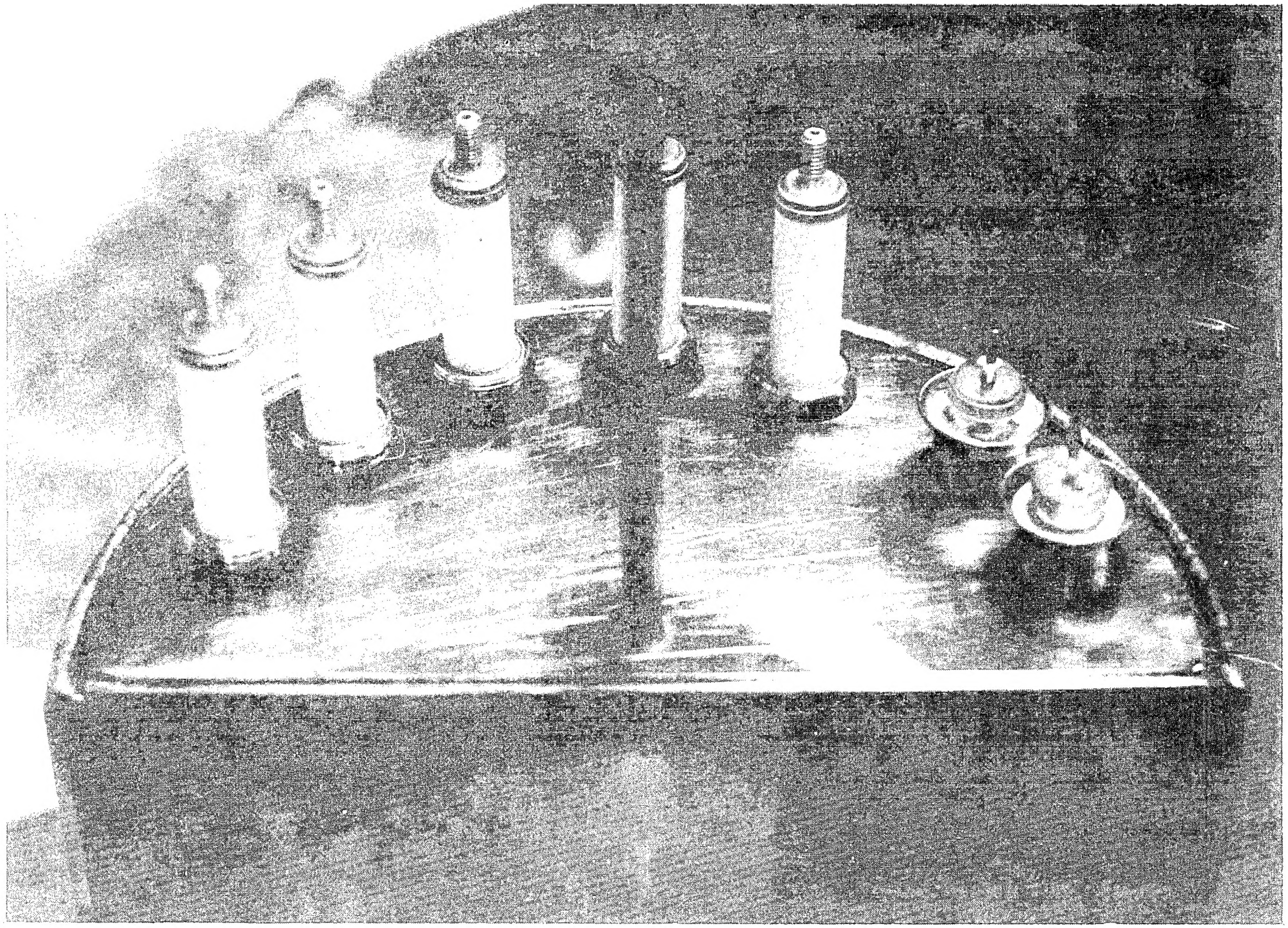


FIGURE 3   A STATORETTE CAN

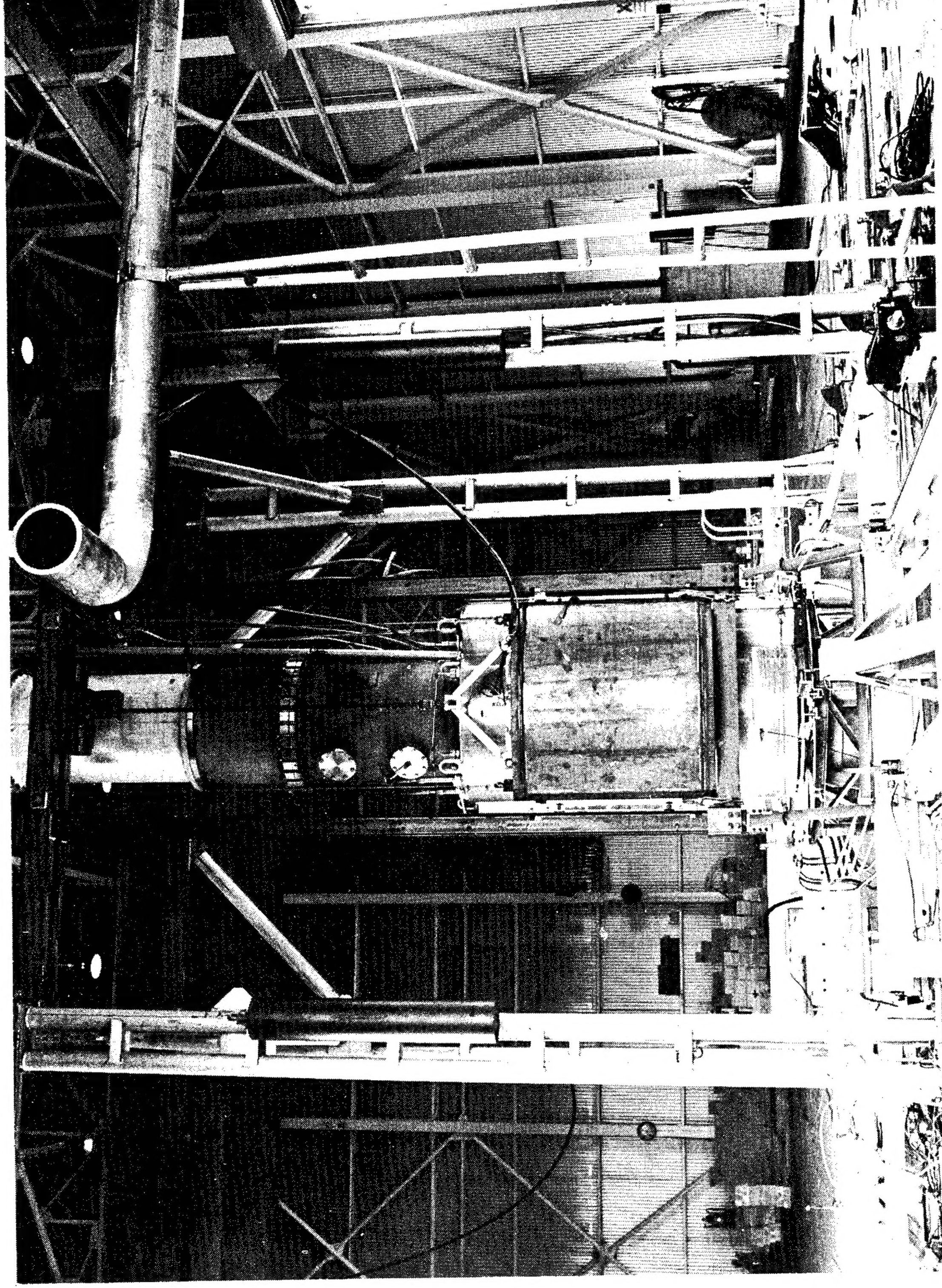


FIGURE 4 THE LITHIUM HYDRIDE SHIELD IN PLACE AT THE RER

TABLE 1

TEMPERATURE HISTORY OF THE IRRADIATED INSULATION MATERIALS

Elapsed Time (Hours)	TEMPERATURE °F						
	T_1	T_2	T_3	T_4	T_5	T_6	T_7
0	62	62	63	62	62	63	62
1	229	234	233	--	228	--	--
2	391	393	392	--	389	375	--
5	390	394	390	370	392	387	375
6	393	394	393	372	393	387	375
9	393	394	393	381	394	389	378
12	393	394	394	384	395	389	381
16	392	393	393	387	394	391	382
19	394	395	394	388	394	392	382
22	393	396	394	387	394	392	382
28	393	395	394	387	394	391	379
34	395	395	394	387	394	391	379
39	395	396	396	388	398	393	384
43	392	392	393	385	394	390	382

The chamber temperatures remained stable to the end of the test with normal minor variations.

1.0 TEST SPECIMENS

GROUP I MAGNET WIRE

I-1 Magnet Wire - Heavy Pyre-ML Film on Copper, AWG 18, Anaconda Wire and Cable Company.

I-2 Magnet Wire - Anaconda H97M Film over Copper, AWG 18, No. H97M Anaconda Wire and Cable Company.

I-3 Magnet Wire - Ceramic Enamel over Nickel Clad Copper, AWG 18; Type HGEK Anacote.

I-4 Magnet Wire - Ceramic Enamel over Nickel Clad Copper, AWG 18, Ceramic-eze, Phelps Dodge Company.

1.1 PROCEDURE

The procedures as outlined in the "Experimental Design Manual," ND 5001, Revised 27 April 1964, was followed except as follows:

1.1.1 Insulation Resistance (Group I-1, I-2)

Insulation resistance measurements were made using the Keithley Model 515 Megohm Bridge instead of the General Radio Model 544B Megohm Bridge.

1.1.2 Insulation Resistance (Group I-3, I-4)

An internal voltage of 50 VDC was used in conjunction with the General Radio Model 544-B instead of the internal supply of 500 VDC. The hygroscopic properties of ceramic insulation necessitated placing the specimens in an oven at 180° F for approximately 30 minutes prior to measurement. Measurements were made while the specimens were in the oven and at 180° F.

1.1.3 Dielectric Strength (Group I-3, I-4)

The Design Manual Procedure, ND 5001, Revised 27 April 1964, was followed except that immediately prior to breakdown test, the specimens were placed in an oven at 180° F and allowed to remain for approximately 30 minutes. The specimens were than removed individually and tested.

1.1.4

A neon glow lamp was inserted in the circuit with a resistor and designed to permit firing at 5 ma.

1.2 NUCLEAR ENVIRONMENT

	NEUTRON FLUX		GAMMA DOSE	
Material	Rate $n/cm^2/sec$	Integrated n/cm	Rate Rads/hr.	Integrated Rads
1	8.4×10^7	4.1×10^{13}	6.8×10^5	9.3×10^7
2	8.0×10^7	4.0×10^{13}	6.1×10^5	8.4×10^7
3	8.1×10^7	4.0×10^{13}	6.8×10^5	9.3×10^7
4	6.7×10^7	3.3×10^{13}	6.2×10^5	8.5×10^7

1.3 RESULTS

1.3.1 Twisted Pair Wire

1.3.1.1 ac Proof Test

All specimens were subjected to an ac proof test with satisfactory results. The I-3 and I-4 specimens exhibited leakage currents of 5 milliamps or greater with 300 volts ac applied; however, this occurred only at room ambient conditions. Proof tests performed while in the oven, after drying, were satisfactory. The specimens

were removed from the oven and the test voltage applied intermittently. No more than five minutes at room ambient were required for the specimens to absorb enough moisture to equal or exceed the 5 milliamp allowed leakage current. The specimens were considered to have passed the proof test.

1.3.1.2 Insulation Resistance

1.3.1.2.1 Group I-1

The results of the insulation resistance measurements are shown in Table 1-1. It is well to note that the median value of the irradiated specimens are somewhat lower than the control and as received. This difference in value, however, is insignificant when considering most insulation material applications. Note also that there is a small differerence between the "as received" and temperature control specimens. This difference could be attributed to the additional curing time provided by the control run or simply a variation in the samples.

1.3.1.2.2 Group I-2

The results of the insulation resistance measurements are shown in Table 1-2. A difference was observed in the three groups of specimens. The control group exhibited the highest values, however, the difference between the three seems to be of little significance. This difference is probably due to the additional curing afforded by the control run.

1.3.1.2.3 Group I-3

The results of the insulation resistance measurements are shown in Table 1-3. No conclusions can be drawn in regard to temperature and radiation effects due to wide scatter in the data.

1.3.1.2.4 Group I-4

The results of the insulation resistance measurements are shown in Table 1-4. No significant effects were noticed.

1.3.1.3.2 Group I-2

The results of the dielectric breakdown tests are shown in Table 1-2. A significant difference in the median breakdown voltage of the control specimens was observed and was in the order of 30% of the other two groups. A slight color change or darkening of the insulation also occurred in the control group. The radiation apparently increased the tolerance of the material to heat. This phenomena is not rare and has been reported with other insulation materials.

1.3.1.3.3 Group I-3

The results of the dielectric breakdown tests are shown in Table 1-3. There appears to be some effects due to both temperature and radiation with the radiation group showing the greater difference. It should be noted, however, that there was considerable difficulty encountered in making these measurements because of the hygroscopic property of ceramic materials.

1.3.1.3.4 Group I-4

The results of the dielectric breakdown tests are shown in Table 1-4. No significant effects were noticed.

1.3.2 Single Wire

1.3.2.1 Capacitance and Dissipation

1.3.2.1.1 Group I-1

The results of the capacitance and dissipation measurements are shown in Table 1-5. No significant effects were noticed.

1.3.2.1.2 Group I-2

The results of the capacitance and dissipation measurenents are shown in Table 1-6. No significant effects were noticed.

1.3.2.1.3 Group I-3, I-4

These tests were not conducted because the mercury in the bath penetrated the ceramic insulation and shorted to the bare copper. Other methods would not have given the repeatability of measurements desired.

TABLE 1-1
INSULATION RESISTANCE AND DIELECTRIC STRENGTH
(TWISTED PAIR GROUP I MAGNET WIRE)

Identification	Specimen Identification	Insulation Resistance (Ω)	Dielectric Breakdown Voltage (VAC RMS)
"As Received"	I-1AP-1	$> 3.3 \times 10^{14}$	18,000
	-2	$> 2.9 \times 10^{14}$	7,000
	-3	$> 5.7 \times 10^{14}$	13,300
	-4	$> 1.4 \times 10^{14}$	13,800
	I-1AP-5	$> 9.0 \times 10^{14}$	14,600
"Control"	I-1CP-6	$> 7.2 \times 10^{14}$	13,600
	-7	$> 2.0 \times 10^{14}$	16,000
	-8	$> 1.0 \times 10^{15}$	12,800
	-9	$> 2.8 \times 10^{14}$	13,700
	I-1CP-10	$> 7.7 \times 10^{14}$	13,700
"Irradiated"	I-1RP-11	$> 1.0 \times 10^{14}$	9,200
	-12	$> 1.4 \times 10^{14}$	14,000
	-13	$> 2.0 \times 10^{14}$	14,200
	-14	$> 1.4 \times 10^{14}$	12,900
	I-1RP-15	$> 1.5 \times 10^{14}$	9,200

TABLE 1-2
INSULATION RESISTANCE AND DIELECTRIC STRENGTH
(TWISTED PAIR GROUP I-2 MAGNET WIRE)

Identification	Specimen Identification	Insulation Resistance (Ω)	Dielectric Breakdown Voltage (VAC RMS)
"As Received	I-2AP-1	$> 1.8 \times 10^{13}$	8,200
	-2	$> 1.0 \times 10^{14}$	8,300
	-3	$> 2.2 \times 10^{14}$	6,000
	-4	$> 4.6 \times 10^{14}$	3,000
	I-2AP-5	$> 2.7 \times 10^{14}$	6,400
"Control"	I-2CP-6	$> 1.0 \times 10^{15}$	2,800
	-7	$> 1.0 \times 10^{15}$	2,400
	-8	$> 1.0 \times 10^{15}$	2,000
	-9	$> 1.0 \times 10^{15}$	2,200
	I-2CP-10	$> 1.0 \times 10^{15}$	2,300
"Irradiated"	I-2RP-11	$> 4.5 \times 10^{14}$	6,600
	-12	$> 5.5 \times 10^{14}$	7,800
	-13	$> 4.6 \times 10^{14}$	8,000
	-14	$> 4.3 \times 10^{14}$	8,000
	I-2RP-15	$> 1.8 \times 10^{14}$	7,400

TABLE 1-3
INSULATION RESISTANCE AND DIELECTRIC STRENGTH
(TWISTED PAIR GROUP I-3 MAGNET WIRE)

Identification	Specimen Identification	Insulation Resistance (Ω)	Dielectric Breakdown Voltage (VAC - RMS)
"As Received"	I-3AP-1	2.1×10^{7}	480
	-2	8.5×10^{7}	600
	-3	2.8×10^{8}	500
	-4	3.9×10^{8}	400
	I-3AP-5	1.9×10^{8}	480
"Control"	I-3CP-6	1.5×10^{10}	500
	-7	1.2×10^{9}	200
	-8	2.0×10^{11}	140
	-9	7.2×10^{6}	180
	I-3CP-10	1.7×10^{9}	300
"Irradiated"	I-3RP-11	1.0×10^{7}	140
	-12	7.4×10^{8}	130
	-13	1.4×10^{7}	160
	-14	9.5×10^{7}	120
	I-3RP-15	7.4×10^{7}	60

TABLE 1-4
INSULATION RESISTANCE AND DIELECTRIC STRENGTH
(TWISTED PAIR GROUP I-4 MAGNET WIRE)

Identification	Specimen Identification	Insulation Resistance (Ω)	Dielectric Breakdown Voltage (VAC - RMS)
"As Received"	I-4AP-1	1.3×10^{9}	240
	-2	2.7×10^{9}	260
	-3	1.9×10^{9}	240
	-4	2.2×10^{9}	300
	I-4AP-5	1.0×10^{12}	280
"Control"	I-4CP-6	2.2×10^{9}	210
	-7	5.0×10^{11}	320
	-8	$> 1.0 \times 10^{12}$	240
	-9	2.2×10^{9}	260
	I-4CP-10	1.6×10^{9}	340
"Irradiated"	I-4RP-11	5.0×10^{11}	280
	-12	2.6×10^{9}	180
	-13	2.8×10^{9}	140
	-14	1.0×10^{11}	340
	I-4RP-15	2.3×10^{9}	320

TABLE 1-5
CAPACITANCE AND DISSIPATION
(SINGLE WIRE - GROUP I - 1 MAGNET WIRE)

Identification	Specimen Identification	Capacitance (pF)	Dissipation Factor Percent
"As Received"	I-1A-1	693.684	0.0048
	-2	702.406	0.0040
	-3	708.208	0.0045
	-4	708.678	0.0048
	I-1A-5	703.286	0.0047
"Control"	I-1C-6	686.056	0.0045
	-7	711.426	0.0056
	-8	704.714	0.0050
	-9	707.022	0.0049
	I-1C-10	704.369	0.0051
"Irradiated"	I-1R-11	693.956	0.0047
	-12	698.583	0.0051
	-13	680.338	0.0063
	-14	671.334	0.0053
	I-1R-15	689.747	0.0054

TABLE 1-6
CAPACITANCE AND DISSIPATION
(SINGLE WIRE - GROUP I - 2 MAGNET WIRE)

Identification	Specimen Identification	Capacitance (pF)	Dissipation Factor Percent
"As Received"	I-2-A1	993.846	0.0149
	-A2	1008.96	0.0100
	-A3	1016.26	0.0096
	-A4	1024.16	0.0094
	I-2-A5	993.323	0.0101
"Control"	I-2-C6	1024.47	0.0103
	-C7	1045.71	0.0106
	-C8	1056.50	0.0112
	-C9	768.35*	0.0119
	I-2-C10	769.13*	0.0181
"Irradiated"	I-2-R11	1056.14	0.0114
	-R12	1047.96	0.0119
	-R13	1029.34	0.0117
	-R14	761.70*	0.0117
	I-2-R15	759.54*	0.0129

*Less than 12" lengths

2.0 TEST SPECIMENS

GROUP II FLEXIBLE LEAD WIRE

II-1 Asbestos and Fiber, Phosroc III, Type RSS-5-203, New Haven, Conn. AWG 12 standard.

II-2 Mica paper and Fiberglas insulation, nickel clad strands, AGW 12, Mica-Temp RSS-5-304, Rockbestos Standard.

II-3 Polyolefin insulation, copper strands, AWG 12, Novathene Type NRT-12, Raychem Corp.

2.1 PROCEDURE

The procedures as outlined in ND-5001, Revised 27 April 1964 were followed. The II-3 specimens were included in both irradiations No. 2 and No. 3 and were not in No. 1 because of temperature considerations.

2.2 NUCLEAR ENVIRONMENT

	NEUTRON FLUX		GAMMA DOSE	
Materials	Rate $n/cm^2/sec$	Integrated n/cm	Rate Rads/hr.	Integrated Rads
1	8.4×10^7	4.1×10^{13}	7.1×10^5	9.8×10^7
2	9.1×10^7	4.5×10^{13}	8.0×10^5	1.1×10^8
3		6.3×10^{13}		9.7×10^6

2.3 RESULTS

2.3.1 II-1 and II-2 Materials

All specimens showed a change in color with the irradiated specimens being

slightly darker. (See Table 2.1).

2.3.2 II-3 Material

No apparent color changes were noted.

2.3.3 Weight Change

All specimens showed some change in weight (See Table 2-2); however, there was no significant effect by radiation.

2.3.4 Mandrel Bend Test

All specimens passed - no breaking, cracking or spalling were evident.

TABLE 2-1

COLOR CHANGE

FLEXIBLE LEAD

WIRE II-1, II-2

Specimen Number	Apparent Visual Change
II-1-C7	Chalky white to grey
II-1-R13	Chalky white to yellow grey
II-2-C7	Grey to light brown
II-2-R13	Grey to dark brown

TABLE 2-2

WEIGHT CHANGE,

II-1, -2, -3

Material and Specimen Number	WEIGHT, GRAMS		WEIGHT CHANGE*	
	Before Exposure	After Exposure	Grams	Percent
1-C7	16.2039	16.1800	-0.0239**	-0.15
1-R13	16.3074	16.2765	-0.0309**	-0.19
2-C7	13.1460	13.1280	-0.0180	-0.14
2-R13	13.3982	13.3805	-0.0177	-0.13
3-C7	12.8473	12.8485	+0.0012	+0.01
3-R13***	12.9816	12.9811	-0.0005	0.00

* A weight change greater than 1.0% was considered significant.

** Due to the hygroscopic nature of this material its weight was observed to change while on the balance pan. Therefore the initial weight was taken as a reference.

*** Temperature, 160° F.

3.0 TEST SPECIMENS

GROUP III MICA PRODUCT

III-1 Rigid, inorganic bonded amber mica flakes, Product Y26. New England Mica Co., Waltham, Mass.

III-2 Flexible mica flake composite Product No. 66633. MacAllen Mica Co., New Market, N. H.

III-3 Flexible mica paper composite Product No. GE 77873, mica mat, General Electric Co., Schenectady, N. Y.

III-4 Flexible mica paper composite Product No. 806P, MacAllen Mica Co., New Market, N. H.

III-5 Flexible mica paper composite, Product No. SFG-12-5, Mica Insulator Co., Schenectady, N. Y.

III-6 Rigid, Product No. S1342 mica mat, General Electric Co., Schenectady, N. Y.

3.1 PROCEDURE

The procedures as outlined in ND-5001, Revised 27 April 1964, were followed.

3.2 NUCLEAR ENVIRONMENT

	NEUTRON FLUX		GAMMA RATE	
Material	Rate $n/cm^2/sec$	Integrated n/cm	Rate Rads/hr.	Integrated Rads
1	1.1×10^8	5.2×10^{13}	7.8×10^5	1.1×10^8
2	7.9×10^7	3.9×10^{13}	7.1×10^5	9.8×10^7
3	7.9×10^7	3.9×10^{13}	7.7×10^5	1.1×10^8
4	9.2×10^7	4.6×10^{13}	7.5×10^5	1.0×10^8
5	7.7×10^7	3.7×10^{13}	7.8×10^5	9.8×10^7
6	9.1×10^7	4.5×10^{13}	8.4×10^5	1.1×10^8

3.3 RESULTS

3.3.1 Thickness Change

There was no discernible change in thickness due to radiation. (See Tables 3-1, 3-2 and 3-3).

3.3.2 Weight Change

Both Control, 200° C and Irradiated specimens showed a small change in weight; however, the effect of radiation was not significant (See Tables 3-4, 3-5 and 3-6). Material 3C-7 showed a significant temperature effect, with a decrease of 1.1%.

3.3.3 Visual

3.3.3.1 III-1 and III-6 Materials

No color change.

3.3.3.2 III-2, III-3, III-4, and III-5 Materials

All specimens showed a slight change in color with the irradiated specimens being somewhat darker (See Table 3-7).

3.3.4 Flexural Strength

The equipment used in the flexural strength tests is shown in Figures 3-1 and 3-2.

3.3.4.1 III-1 Material

An environmental effect on flexural strength was found for the Temperature and Control and Irradiated specimens. There was a decrease of about 29 percent due to radiation (See Table 3-8).

3.3.4.2 III-6 Material

No significant effect of radiation on flexural strength was noted; however, there was a temperature effect causing a decrease of 13 percent in flexural strength (See Table 3-9).

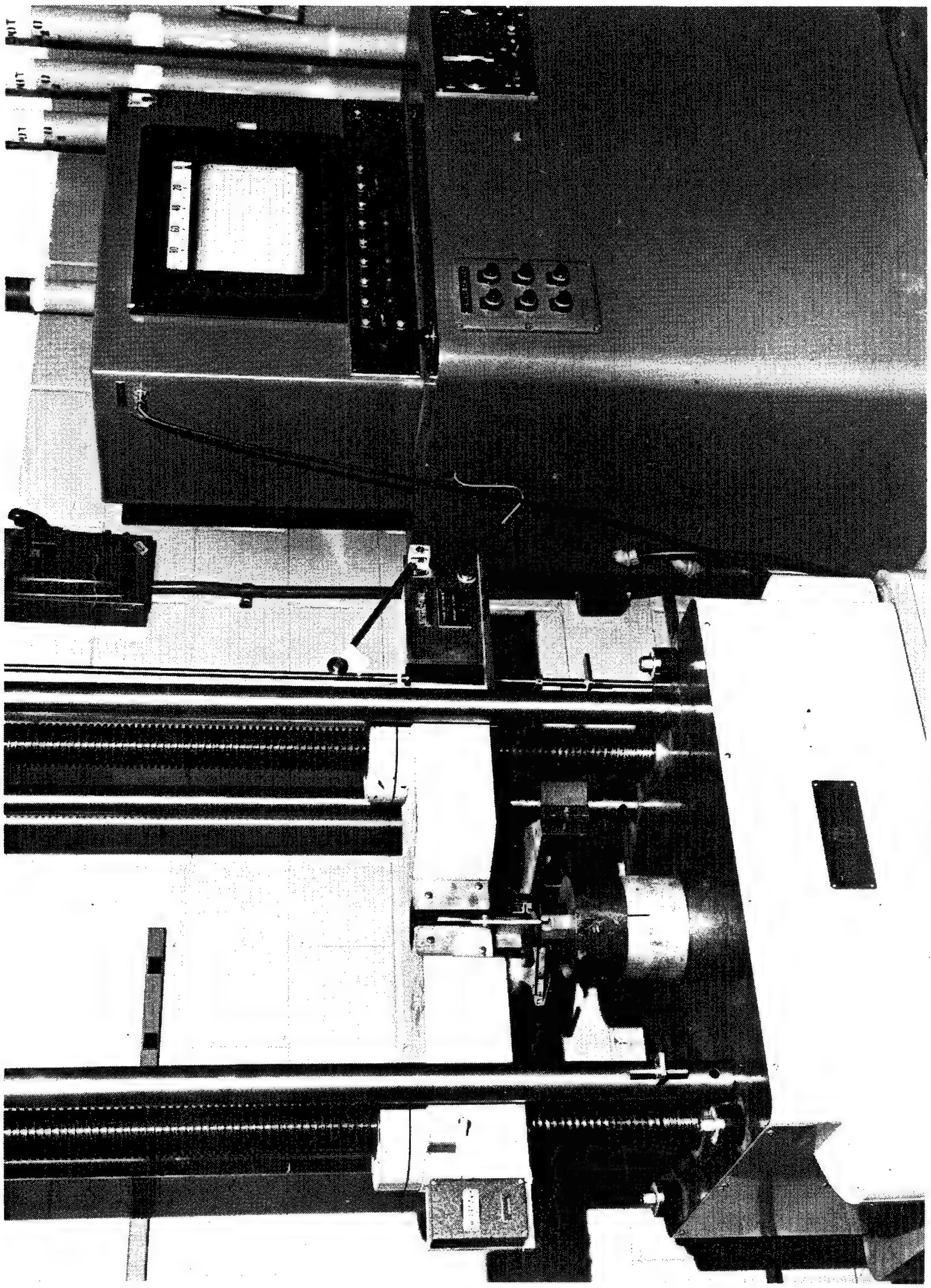


FIGURE 3-1 FLEXURAL TEST SETUP

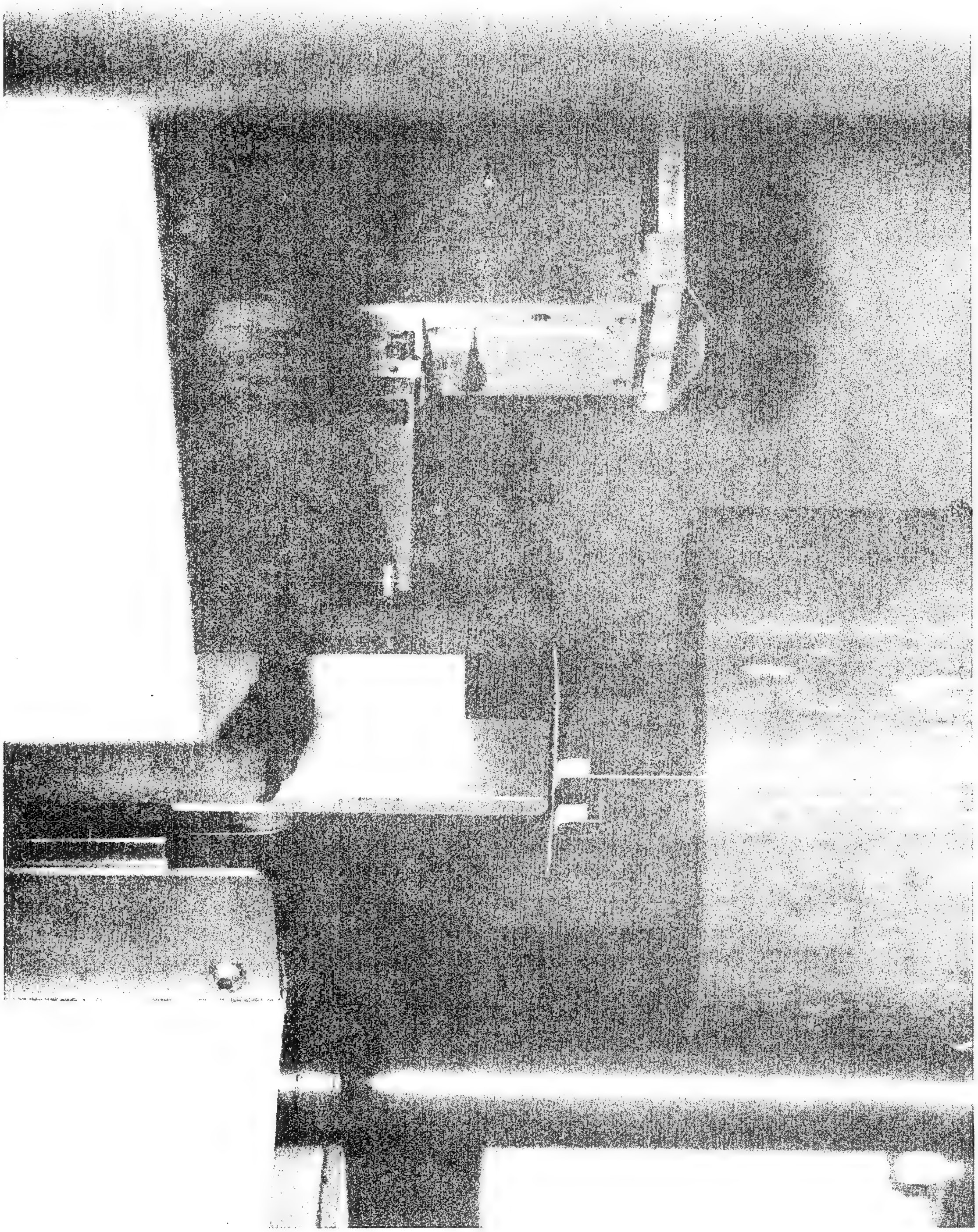


FIGURE 3-2 FLEXURAL TEST SETUP

TABLE 3-1

THICKNESS CHANGE, III-1

Specimen Number	BEFORE EXPOSURE THICKNESS, MILS Pt. 1	Pt. 2	Pt. 3	Pt. 4	Pt. 5	Pt. 6	Average mils	AFTER EXPOSURE THICKNESS, MILS Pt. 1	Pt. 2	Pt. 3	Pt. 4	Pt. 5	Pt. 6	Average mils	AVERAGE THICKNESS CHANGE mils	Percent
C-7 C-8	24.7 35.0	25.2 33.0	28.5 28.7	26.0 31.6	27.0 30.9	27.4 31.2	26.5 31.7	23.0 34.5	23.4 34.0	25.4 30.5	28.5 30.0	25.4 32.0	27.0 31.0	25.5 32.0	-1.0 +0.3	-3.8 +0.9
C-9 C-10	32.7 29.2	30.5 28.3	26.5 28.6	28.2 29.4	32.5 31.0	32.7 31.6	30.5 29.7	32.5 29.0	31.0 27.5	26.0 27.8	29.0 28.3	31.0 29.7	32.5 31.5	30.3 29.0	-0.2 -0.7	-0.7 -2.4
C-11 C-12	32.5 27.3	32.7 24.2	32.7 24.7	32.7 23.8	31.2 25.5	30.3 27.3	32.0 25.5	26.8 27.0	31.0 24.6	32.0 23.5	32.0 24.0	32.2 24.4	36.5 27.6	31.7 25.2	-0.3 -0.3	-0.9 -1.2
AVERAGE (RANGE															-0.4 (-1.01, +0.3)	-1.3 (-3.8 +0.9)
R-13 R-14	39.5 25.5	43.1 27.7	41.7 27.0	39.1 31.8	38.0 34.3	34.7 32.7	39.4 29.8	37.6 32.7	38.4 33.2	40.7 30.0	41.7 26.3	43.4 27.5	40.2 26.3	40.3 29.3	+0.9 -0.5	+2.3 -1.7
R-15 R-16	32.7 27.4	30.2 28.5	32.1 29.0	28.2 28.5	30.7 32.3	31.0 28.7	30.8 29.1	32.6 30.5	29.8 32.4	32.1 30.2	29.3 27.4	29.5 30.0	31.0 26.5	30.7 29.5	-0.1 +0.4	-0.3 +1.4
R-17 R-18	31.7 34.0	33.0 34.0	26.6 34.5	26.0 29.8	28.3 29.5	27.0 28.2	28.7 31.7	31.7 27.6	33.8 31.0	27.6 32.7	25.0 34.8	26.8 33.6	28.7 32.5	28.9 32.0	+0.2 +0.3	+0.7 +0.9
AVERAGE (RANGE)															+0.5 (-0.5, +0.9)	+0.5 (-1.7 +2.3)

NOTE: A thickness change not greater than ± 0.5 mils is considered to be insignificant.

TABLE 3-2

THICKNESS CHANGE,

III-2, -3, -4, AND -5

Material And Specimen Number	BEFORE EXPOSURE THICKNESS, MILS Pt. 1	Pt. 2	Pt. 3	Pt. 4	Pt. 5	Pt. 6	Average mils	AFTER EXPOSURE THICKNESS, MILS Pt. 1	Pt. 2	Pt. 3	Pt. 4	Pt. 5	Pt. 6	Average mils	AVERAGE THICKNESS CHANGE mils	Percent
2C-7	10.8	8.5	6.3	9.1	8.2	9.5	8.7	10.0	9.2	8.7	9.0	7.7	10.8	9.2	+ 0.5	+ 5.7
	5.3	6.1	8.5	7.0	8.0	8.0	7.2	5.0	6.3	7.0	7.0	6.6	8.2	6.7	- 0.5	- 6.9
3C-7	3.6	3.3	3.4	3.6	3.5	3.6	3.5	3.8	3.7	3.7	3.6	3.8	3.7	3.7	+ 0.2	+ 5.7
3R-13	3.8	3.5	3.5	3.5	3.6	3.4	3.6	3.8	3.7	3.8	3.9	3.8	3.8	3.8	+ 0.2	+ 5.6
4C-7	9.2	9.5	9.8	9.4	9.5	9.8	9.5	9.8	9.7	9.7	9.4	9.6	9.6	9.6	+ 0.1	+ 1.1
4R-13	9.4	9.5	9.5	9.5	9.5	9.4	9.5	9.6	9.4	9.4	9.3	10.0	9.6	9.6	+ 0.1	+ 1.1
5C-7	7.5	7.5	7.5	7.2	7.5	7.5	7.5	7.5	7.0	7.0	6.9	7.2	7.1	7.1	- 0.4	- 5.3
5R-13	7.2	7.2	7.0	6.8	6.8	7.0	7.0	7.5	7.3	7.0	7.4	7.1	6.9	7.2	+ 0.2	+ 2.9

NOTE: A thickness change not greater than $\pm$ 0.5 mils is considered to be insignificant.

TABLE 3-3

THICKNESS CHANGE, III-6

Specimen Number	BEFORE EXPOSURE THICKNESS, MILS Pt. 1	Pt. 2	Pt. 3	Pt. 4	Pt. 5	Pt. 6	Average mils	AFTER EXPOSURE THICKNESS, MILS Pt. 1	Pt. 2	Pt. 3	Pt. 4	Pt. 5	Pt. 6	Average mils	AVERAGE THICKNESS CHANGE mils	Percent
C-7	37.2	36.7	36.7	37.0	37.0	37.0	36.9	36.5	36.9	36.7	36.8	36.9	37.0	36.8	-0.1	-0.3
C-8	36.6	36.5	36.6	36.7	37.0	36.6	36.7	36.5	36.7	36.3	36.7	36.6	36.5	36.6	-0.1	-0.3
C-9	37.0	37.2	36.7	37.1	37.0	38.0	37.2	37.6	36.8	37.0	36.9	36.6	36.7	37.1	-0.1	-0.3
C-10	37.5	36.7	37.2	36.5	37.5	36.7	37.0	36.5	36.9	37.0	36.7	37.0	36.8	36.8	-0.2	-0.5
C-11	36.2	35.7	35.5	35.5	35.7	35.7	35.7	35.7	35.6	35.5	35.4	35.7	35.7	35.6	-0.1	-0.3
C-12	37.0	36.5	36.7	36.8	36.8	37.0	36.8	36.9	36.8	37.0	36.9	36.8	36.7	36.9	+0.1	+0.3
AVERAGE (RANGE)															-0.1 (-0.21 +0.1)	-0.2 (-0.51 10.3)
R-13	36.4	36.4	36.2	35.5	36.2	36.0	36.1	36.2	36.7	36.4	35.8	35.8	36.7	36.2	+0.1	+0.3
R-14	38.1	36.7	37.0	36.5	37.0	36.5	36.8	36.7	36.6	36.8	37.0	37.1	36.8	36.8	0.00	0.0
R-15	36.7	36.2	36.5	36.3	36.6	36.0	36.4	36.5	36.5	36.3	36.0	36.7	35.9	35.9	-0.2	-0.5
R-16	36.8	37.0	37.0	36.8	37.0	36.8	36.9	36.6	36.6	36.8	37.0	37.0	36.5	36.5	-0.1	-0.3
R-17	36.0	35.5	35.7	35.7	36.1	36.4	35.9	36.3	35.8	35.9	35.9	35.5	36.2	36.2	-0.1	-0.3
R-18	36.5	37.0	37.0	37.0	36.7	37.2	36.9	36.5	37.2	36.8	36.8	37.2	37.0	37.0	0.00	0.0
AVERAGE (RANGE)															-0.1 (-0.21 +0.1)	-0.1 (-0.51 +0.3)

NOTE: A thickness change not greater than ± 0.5 mils is considered to be insignificant.

TABLE 3-4
WEIGHT CHANGE, III-1

Specimen Number	WEIGHT, GRAMS		WEIGHT CHANGE	
	Before Exposure	After Exposure	Grams	Percent
C-7	2.4929	2.4927	-0.0002	-0.008
C-8	2.8905	2.8905	0.0000	0.000
C-9	2.9549	2.9549	0.0000	0.000
C-10	2.6448	2.6446	-0.0002	-0.008
C-11	3.0522	3.0521	-0.0001	-0.003
C-12	2.4675	2.4673	-0.0002	-0.008
AVERAGE (RANGE)			-0.0001 (-0.0002/ 0.0000)	-0.005 (-0.008/ 0.000)
R-13	3.6483	3.6477	-0.0005	-0.014
R-14	2.7080	2.7074	-0.0006	-0.022
R-15	2.9661	2.9652	-0.0009	-0.030
R-16	2.7370	2.7364	-0.0006	-0.022
R-17	2.7585	2.7582	-0.0003	-0.011
R-18	2.9600	2.9593	-0.0007	-0.024
AVERAGE (RANGE)			-0.0006 (-0.0009/ -0.0003)	-0.021 (-0.030/ -0.011)

TABLE 3-5
WEIGHT CHANGE, III-2,
-3, -4, AND -5

MATERIAL & SPECIMEN NUMBER	WEIGHT, GRAMS		WEIGHT CHANGE	
	Before Exposure	After Exposure	Grams	Percent
2C-7	1.6125	1.5944	-0.0181	-1.12
2R-13	1.2623	1.2515	-0.0108	-0.86
3C-7	0.3863	0.3835	-0.0028	-0.72
3R-13	0.3601	0.3574	-0.0027	-0.75
4C-7	1.7312	1.7250	-0.0062	-0.36
4R-13	1.7199	1.7125	-0.0074	-0.43
5C-7	1.3597	1.3535	-0.0062	-0.46
5R-13	1.3283	1.3211	-0.0072	-0.54

TABLE 3-6
WEIGHT CHANGE,
III-6

Specimen Number	WEIGHT, GRAMS		WEIGHT CHANGE	
	Before Exposure	After Exposure	Grams	Percent
C-7	3.1100	3.1094	-0.0006	-0.02
C-8	3.1283	3.1279	-0.0004	-0.01
C-9	3.1781	3.1774	-0.0007	-0.02
C-10	3.1791	3.1784	-0.0007	-0.02
C-11	3.1455	3.1449	-0.0006	-0.02
C-12	3.0967	3.0959	-0.0008	-0.03
AVERAGE (RANGE)			-0.0006 (-0.0008/ -0.0004)	-0.02 (-0.03/ -0.01)
R-13	3.1238	3.1234	-0.0004	-0.01
R-14	3.1341	3.1338	-0.0003	-0.01
R-15	3.1050	3.1045	-0.0005	-0.02
R-16	3.1434	3.1429	-0.0004	-0.01
R-17	3.1496	3.1492	-0.0004	-0.01
R-18	3.1584	3.1580	-0.0004	-0.01
AVERAGE (RANGE)			-0.0004 (-0.0005/ -0.0003)	-0.01 (-0.02/ -0.01)

NOTE: A weight greater than $\pm$ 0.0002 gram was considered significant.

TABLE 3-7
COLOR CHANGE
III-1, -2, -3, -4, -5 AND -6

MATERIAL AND SPECIMEN NUMBER	APPARENT COLOR CHANGE
1C7-12 1R13-18	No change in amber color No change in amber color
2C7 2-R13	Yellow grey color darkened Yellow grey color darkened
3-C7 3-R13	Light tan color slightly darkened Light tan color darkened
4-C7 4-R-13	Grey color changed to light tan Grey color changed to dark tan
5-C7 5-R13	Very light tan to tan Very light tan to dark tan
6-C7-12 6-R13-18	Silver grey color unchanged Silver grey color unchanged

TABLE 3-8
FLEXURAL STRENGTH, III-1

Specimen Number	FLEXURAL STRENGTH, PSI			
	psi	Average	Minimum	Maximum
III-1-A1	26,500	28,100	25,300	32,400
-A2	25,300			
-A3	32,000			
-A4	25,800			
-A5	26,700			
-A6	32,400			
-C7	28,800	26,400	20,700	30,400
-C8	25,300			
-C9	20,700			
-C10	20,900			
-C11	26,500			
-C12	30,400			
-R13	18,700	21,300	17,200	29,800
-R14	18,100			
-R15	20,500			
-R16	23,600			
-R17	29,800			
-R18	17,200			

TABLE 3-9
FLEXURAL STRENGTH, III-6

Specimen Number	FLEXURAL STRENGTH, PSI			
	psi	Average	Minimum	Maximum
III-6-A1	27,000	23,800	21,100	30,100
-A2	22,000			
-A3	21,100			
-A4	21,700			
-A5	30,100			
-A6	20,900			
-C7	17,400	20,600	17,400	24,300
-C8	21,200			
-C9	22,000			
-C10	21,200			
-C11	24,300			
-C12	17,600			
-R13	23,700	20,800	17,300	23,700
-R14	20,100			
-R15	20,900			
-R16	20,600			
-R17	22,400			
-R18	17,300			

4.0 TEST SPECIMENS

GROUP IV FIBROUS MATERIAL

IV-1 E-grade fiberglas sleeving to fit AWG-12 wire, Bentley Harris, Conshohocken Product No. 2, Type BH special treated.

IV-2 E-grade fiberglas woven tape Product No. B weave, heat cleaned, Hess Goldsmith Co.

IV-3 E-grade fiberglas, plain weave cloth, Style 116, Trevarno Co.

4.1 PROCEDURE

The procedures as outlined in ND-5001, Revised 27 April 1964, were followed.

4.2 NUCLEAR ENVIRONMENT

Material	NEUTRON FLUX Rate $n/cm^2/sec$	NEUTRON FLUX Integrated n/cm	GAMMA DOSE Rate Rads/hr.	GAMMA DOSE Integrated Rads
1	1.1×10^8	5.4×10^{13}	8.4×10^5	1.1×10^8
2	6.7×10^7	3.3×10^{13}	6.4×10^5	8.8×10^7
3	7.7×10^7	3.7×10^{13}	7.5×10^5	1.0×10^8

4.3 RESULTS

4.3.1 Visual

No apparent color changes were evident.

4.3.2 Breaking Strength

The test equipment used is shown in Figure 4-1.

4.3.2.1 IV-2 Material

No significant effect was observed due to the combined environment of radiation and temperature (See Table 4-1).

4.3.2.3 IV-3 Material

A significant decrease of 15 percent in breaking strength due to a combined effect of radiation and heat was observed (See Table 4-1).

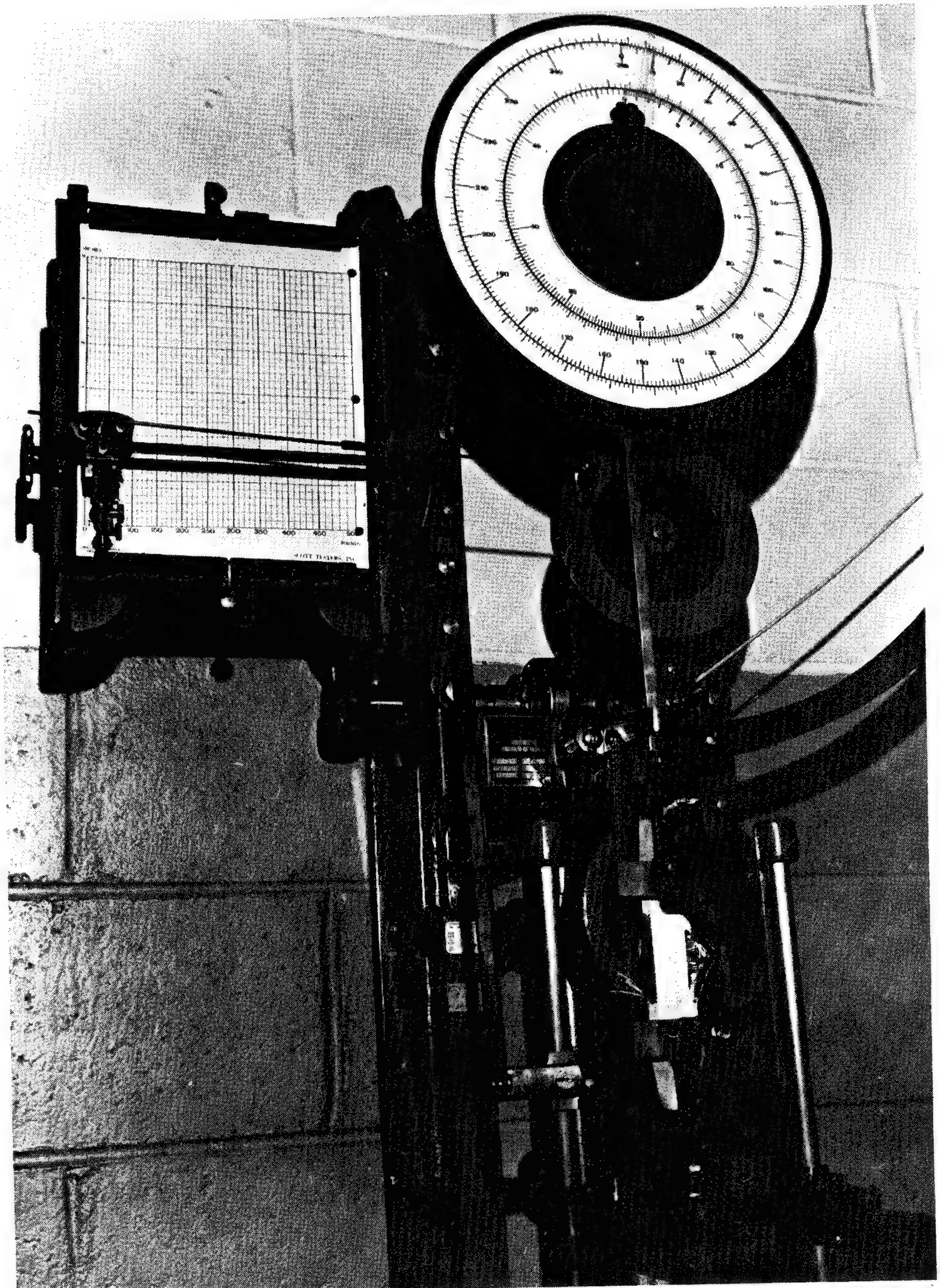


FIGURE 4-1 TENSILE TEST SETUP

TABLE 4-1

BREAKING STRENGTH

IV - 2 AND -3

Material And Specimen Number	BREAKING STRENGTH			
	Pounds	Average	Minimum	Maximum
2-A1	97	101	92	116
-A2	116			
-A3	102			
-A4	96			
-A5	92			
-A6	101			
2-R13	100	100	96	108
-R14	100			
-R15	98			
-R16	108			
-R17	96			
-R18	96			
3-A1	74	73	71	74
-A2	71			
-A3	74			
-A4	73			
-A5	74			
-A6	66*			
3-R13	54*	62	61	63
-R14	62			
-R15	63			
-R16	63			
-R17	63			
-R18	61			

*Failed in clamp; value not included in average.

5.0 TEST SPECIMENS

GROUP V FIBROUS MATERIALS

V-1 Pyre-ML polyimide coated glass fabric, flexible, Quality Code 6508, DuPont Co.

V-2 H-film, polyimide flexible film, DuPont Co., Lot 9263-23.

V-3 Nomex-Ht-1 polyimide flexible paper. DuPont Co., Lot Package 1741, Reference No. 08027.

5.1 PROCEDURE

The procedures as outlined in ND-5001, Revised 27 April 1964, were followed.

5.2 NUCLEAR ENVIRONMENT

Material	NEUTRON FLUX Rate $n/cm^2/sec$	NEUTRON FLUX Integrated n/cm	GAMMA DOSE Rate Rads/hr.	GAMMA DOSE Integrated Rads
1	1.0×10^8	5.0×10^{13}	7.5×10^5	9.8×10^7
2	9.1×10^7	4.5×10^{13}	8.1×10^5	1.1×10^8
3	1.1×10^8	5.4×10^{13}	8.4×10^5	1.1×10^8

5.3 VISUAL

5.3.1.1 V-1 Mayerial

No color change was evident with this group of materials. (See Table 5-1.)

5.3.1.2 V-2 and V-3 Materials

All specimens showed a change in color with the irradiated specimens being the darker (See Table 5-1).

5.3.2 Thickness Change

A small change (< $\pm$ 0.5 mils) in thickness was noticed in all specimens, there appear to be no significant effects due to radiation (See Table 5-2).

5.3.3 Weight Change

5.3.3.1 V-1 Material

No significant effect was observed due to radiation (See Table 5-3).

5.3.3.2 V-2 and V-3 Material

A decrease of approximately 1 to 2 percent was observed for the irradiated specimens (See Table 5-3).

TABLE 5-1
COLOR CHANGE
V-1, -2, AND -3

MATERIAL AND SPECIMEN NUMBER	APPARENT COLOR CHANGE
1-C7 1-R13	Medium brown color unchanged Medium brown color unchanged
2-C7 2-R13	Transparent dark orange color unchanged Orange color slightly darkened
3-C7 3-R13	Pale yellow color slightly darkened Pale yellow color darkened

TABLE 5-2
THICKNESS CHANGE
V-1, -2, AND 3

MATERIAL AND SPECIMEN NUMBER	THICKNESS, MILS														AVERAGE THICKNESS CHANGE	
	BEFORE EXPOSURE							AFTER EXPOSURE								
	Pt. 1	Pt. 2	Pt. 3	Pt. 4	Pt. 5	Pt. 6	Average	Pt. 1	Pt. 2	Pt. 3	Pt. 4	Pt. 5	Pt. 6	Average	Mils	%
1-C7 1-R13	10.6 10.7	10.5 10.5	10.5 10.5	10.5 10.5	10.5 10.5	10.5 10.5	10.5 10.5	10.5 10.5	10.5 10.4	10.5 10.4	10.5 10.4	10.7 10.4	10.7 10.5	10.6 10.4	+0.1 -0.1	+0.96 -0.96
2-C7 2-R13	4.7 1.9	4.2 1.7	3.7 1.7	3.5 2.1	3.5 2.2	3.6 2.4	3.9 2.0	3.9 1.6	3.5 1.6	3.5 1.8	3.9 2.0	4.4 2.0	4.6 2.0	4.0 1.9	+0.1 -0.1	+2.6 -5.0
3-C7 3-R13	10.7 10.0	10.3 10.5	10.3 10.0	10.0 10.0	10.0 10.2	10.0 10.0	10.2 10.1	10.4 10.0	10.4 10.0	10.5 10.2	10.2 10.2	10.1 10.0	10.2 10.3	10.3 10.1	+0.1 0.0	+1.0 0.0

NOTE: A thickness change greater than $\pm$ 0.05 mils is considered significant

TABLE 5-3
WEIGHT CHANGE
V-1, -2, AND 3

MATERIAL AND SPECIMEN NO.	WEIGHT, GRAMS		WEIGHT CHANGE*	
	BEFORE EXPOSURE	AFTER EXPOSURE	GRAMS	PERCENT
1-C7 1-R13	1.9752 2.0232	1.9696 2.0157	-0.0056 -0.0075	-0.28 -0.37
2-C7 2-R13	0.7982 0.4128	0.7969 0.4056	-0.0013 -0.0072	-0.16 -1.74
3-C7 3-R13	1.4736 1.4763	1.4615 1.4604	-0.0121 -0.0159	-0.82 -1.07

* A weight change greater than 1.0% is considered significant.

6.0 TEST SPECIMENS

GROUP VI ORGANIC FLUIDS

VI-1 ET-378, Mixed Bis (Phenoxyphenyl) Ether, Dow Chemical Co., Lot No. 458-29-13, distilled by AGC.

VI-2 OS-124, Mixed Bis (Phenoxyphenoxy) Benezene, Monsanto Chemical Co., Lot No. QC-31.

6.1 PROCEDURE

The procedures as outlined in ND-5001, Revised 27 April 1964, were followed with the following exceptions.

6.1.1 In-Capsule Conditioning

The specimens were held for approximately 12 hours at less than 1 mm Hg. at ambient temperature, then pressurized with 1 psig helium. A fluid control container is shown in Figure 6-1.

6.1.2 Total Acid

0.03158 N KOH was used instead of 0.1 N KOH as specified in the ASTM for better end point detections.

6.1.3 Dielectric Constant

The dielectric constant of the fluids was determined by taking the inverse ratio of the test fixture capacitance when filled with dry nitrogen when filled with the test fluids. This method considers edge effects and permits the determination of a true dielectric constant. Care was taken to see that test fixture geometry remained constant. The test fixture is shown in Figure 6-2.

Attempts to measure the fluids in air were futile because of the high dependence of

the dielectric constant on the air content of the fluids. Air was so rapidly absorbed, after outgassing, that the capacitance bridge was seen to drift off balance at a rapid rate. Stable values were obtained only after thorough out-gassing and with the test fixture and fluid maintained in a vacuum. The pumps were turned off during the measurement time to preclude the possible formation of bubbles as their presence was easily discernible.

6.2 NUCLEAR ENVIRONMENT

Material	NEUTRON FLUX Rate $n/cm^2/sec$	NEUTRON FLUX Integrated n/cm	GAMMA DOSE Rate Rads/Hr.	GAMMA DOSE Integrated Rads
1	6.3×10^7	3.1×10^{13}	7.8×10^5	1.1×10^8
2	6.3×10^7	3.1×10^{13}	7.8×10^5	1.1×10^8

6.3 RESULTS

"As Received, " Control 392° F, and "Irradiated" samples were tested; however, in some tests OS-124 degassed "As Received" samples were not tested due to a spillage loss. The irradiated fluids changed to a cherry-brown color. The irradiated OS-124 fluid had a burning type odor similar to that of an acid.

6.3.1 Out-Gassing

The pyrex glass out-gassing system is shown in Figure 6-3. Data for "As Received" fluids are given in Table 6-1 and 6-2, and for viscosity tested fluids in Tables 6-3 and 6-4. In all samples de-gassed, air or other gasses had been absorbed.

6.3.2 Viscosity

The Fisher Electroviscosimeter is shown in Figure 6-4.

6.3.2.1 VI-1 Fluid

There appears to be no significant change due to radiation (See Table 6-5).

6.3.2.2 VI-2 Fluid

There was an increase of 8 percent in the viscosity of the irradiated fluid at 100° F. There was no significant change due to radiation on the viscosity at 210° F (See Table 6-6).

6.3.3 Four Ball Wear Test

The Precision-Shell Four Ball Wear Tester is shown in Figure 6-5.

6.3.3.1 VI-1 Fluid

Wear data for ET-378 fluid are given in Table 6-7, and data for Shell Rotella Oil (SAE-30) and Mil-L7808E Turbine Oil are given in Table 6-8. There appears to be no significant radiation change at the 10 Kg load; however, at 50 Kg load there is a decrease of approximately 5 percent in scar diameter (average) for the irradiated fluid.

6.3.3.2 VI-2 Fluid

There appears to be no radiation changes (See Table 6-9).

6.3.4 Total Acid

The titration apparatus is shown in Figure 6-6.

6.3.4.1 VI-1 Fluid

There appeared to be no significant change due to radiation (See Table 6-10).

6.3.4.2 VI-2 Fluid

The total acid content of the irradiated fluid increased by a factor of 3 (See Table 6-11).

6.3.5 Refractive Index

The Bausch and Lomb Refractometer with constant temperature bath is shown in Figure 6-7. There appeared to be no significant radiation change (See Table 6-12 and 6-13) in either fluid.

6.3.6 Specific Gravity

The Christian Becker specific gravity balance is shown in Figure 6-8. There was no significant change due to radiation (See Tables 6-14 and 6-15).

6.3.7 Infrared Spectra

Beckman Models IR-4 and DK-2 Spectrophotometers are shown in Figures 6-9 and 6-10.

6.3.7.1 VI-1 Fluid

Near-infrared and infrared differential spectra for Control 392° F fluid showed no difference bands. In the near-infrared region difference bands occurred at 2.86, 2.33, 2.32, 2.22, 2.21, 2.06, 2.00, 1.94, 1.68, and 1.44 microns. In the infrared region difference bands occurred at 2.8, 4.2, 5.85, 5.89 (weak), 6.45, 6.51 and 7.6 microns. There was an increase in absorption at 3.2, 6.2, 9.22, 9.72, 10.08, 11.35 and 12.6 microns. The difference bands suggest the formation of phenolic-type compounds and the occurrence of aromatic ring cleavage.

6.3.7.2 VI-2 Fluid

The near-infrared differential spectra showed no difference band for Control 392° F fluid, where as the irradiated samples showed difference bands at 1.44, 2.06, and 2.85 microns. In the infrared region, Control 392° F fluid had difference bands at 3.2, 6.15, 7.55, 9.23 and 9.95 microns with an apparent increase in absorption at 11.32, 12.55 and 14.25 microns. The irradiated fluid showed difference bands at 2.80, 3.22, 6.15, 7.55, 9.23, 9.75 and 9.95 microns along with weak bands at 5.10, 5.62, 6.45 and 6.53 microns. The difference bands

suggest the formation of phenol or phenolic-type compounds.

6.3.8 Off-Gas Analysis

There was no noticeable increase in container pressure before, during, and after irradiation except that normally due to temperature. The Perkin-Elmer Model 154 Gas Chromatograph is shown in Figure 6-11.

6.3.8.1 VI-1 Fluid

A slight air leak in the gas chromatograph vacuum manifold was observed during off-gas sampling thus possibly accounting for the N_2 and O_2 found. Components of the off-gas consisted of about 64 mole percent hydrogen, and 36 mole percent methane (See Table 6-16). A Carbowax 1500 column was also used which gave a negative peak believed due to water.

6.3.8.2 VI-2 Fluid

A slight air leak in the gas chromatograph vacuum manifold was observed during off-gas sampling thus possibly accounting for the N_2 and O_2 found. Components of the off-gas consisted of about 76 mole percent hydrogen, 2 mole percent methane and 22 mole percent carbon monoxide (See Table 6-17). A Carbowax 1500 column was used which gave a negative peak believed due to water.

6.3.9 Electrical Parameters

The results of the electrical measurements on the organic fluids are shown in Table 6-18. Definite changes are shown by the data in regards to volume resistivity and dissipation factor. On both the ET-378 and OS-124 the volume resistivity decreased two orders of magnitude when irradiated. Likewise the dissipation factor increased from less than 0.00001 to 0.00179 for the ET-378 and 0.00823 for the OS-124. The dielectric breakdown voltage and dielectric constant measurements showed no change between the control and irradiated samples.

FIGURE 6-1 ORGANIC FLUID CONTAINER, CONTROL

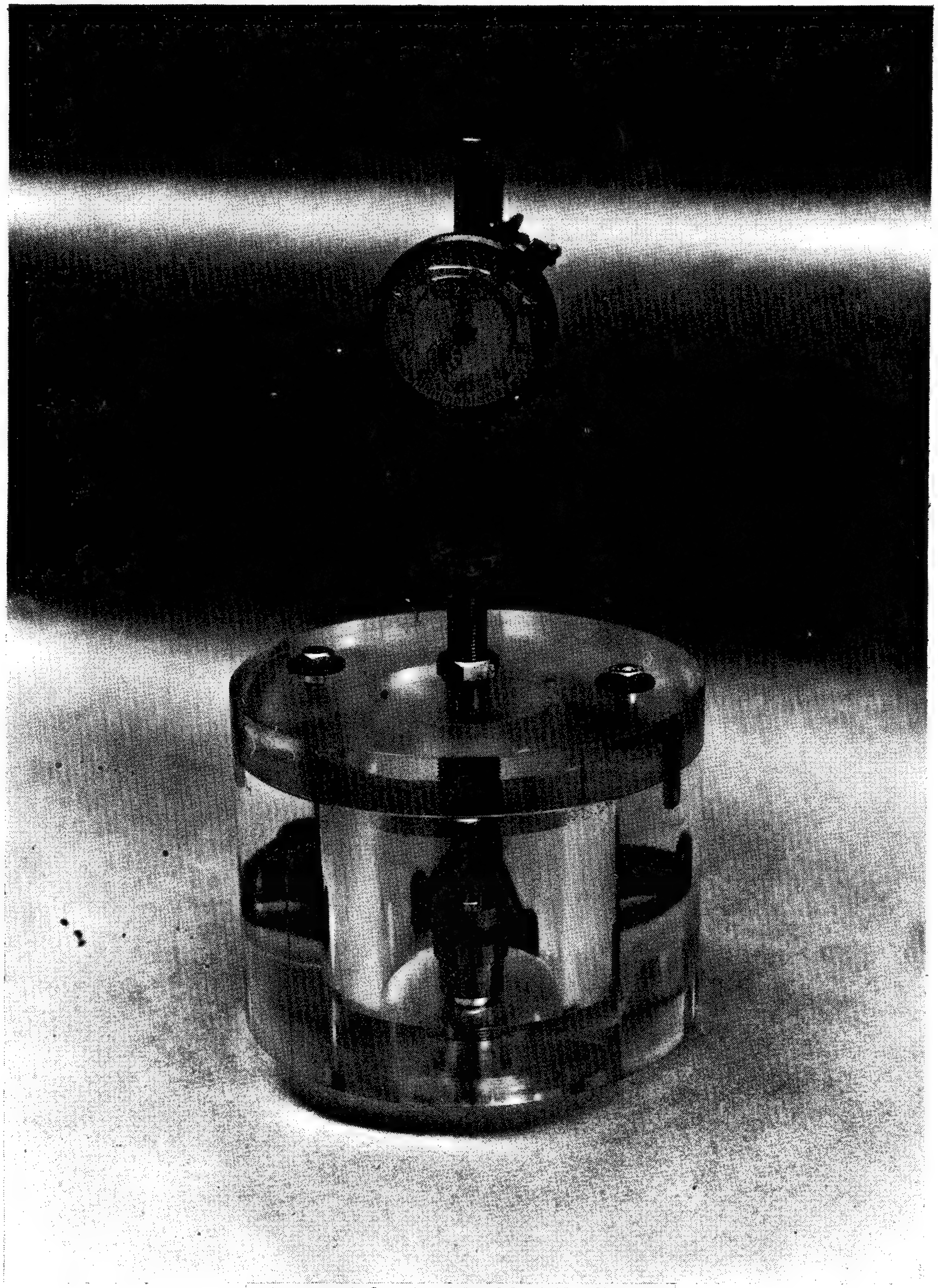


FIGURE 6-2 DIELECTRIC TEST FIXTURE

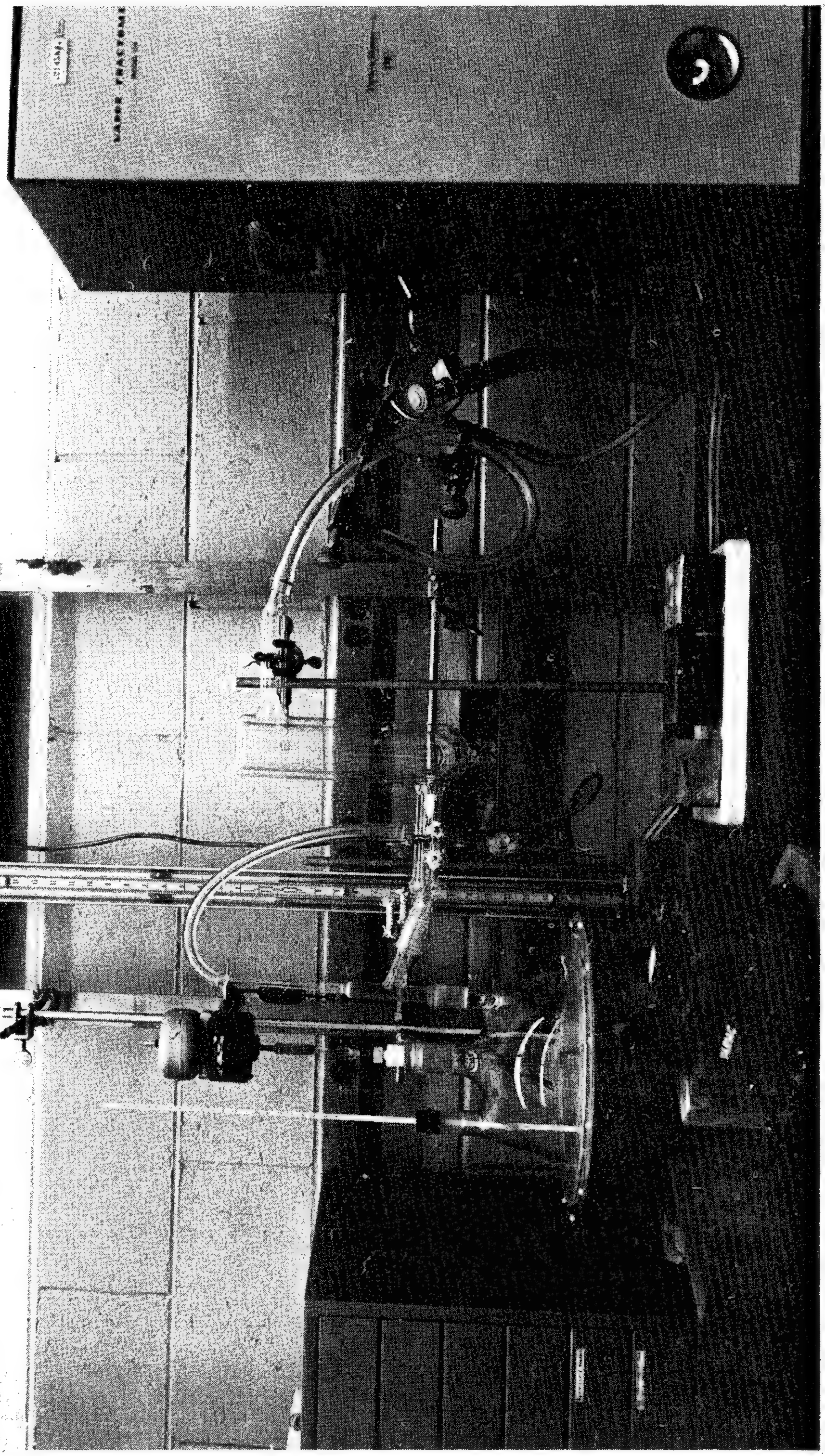


FIGURE 6-3 ORGANIC FLUID OUT-GASSING SYSTEM

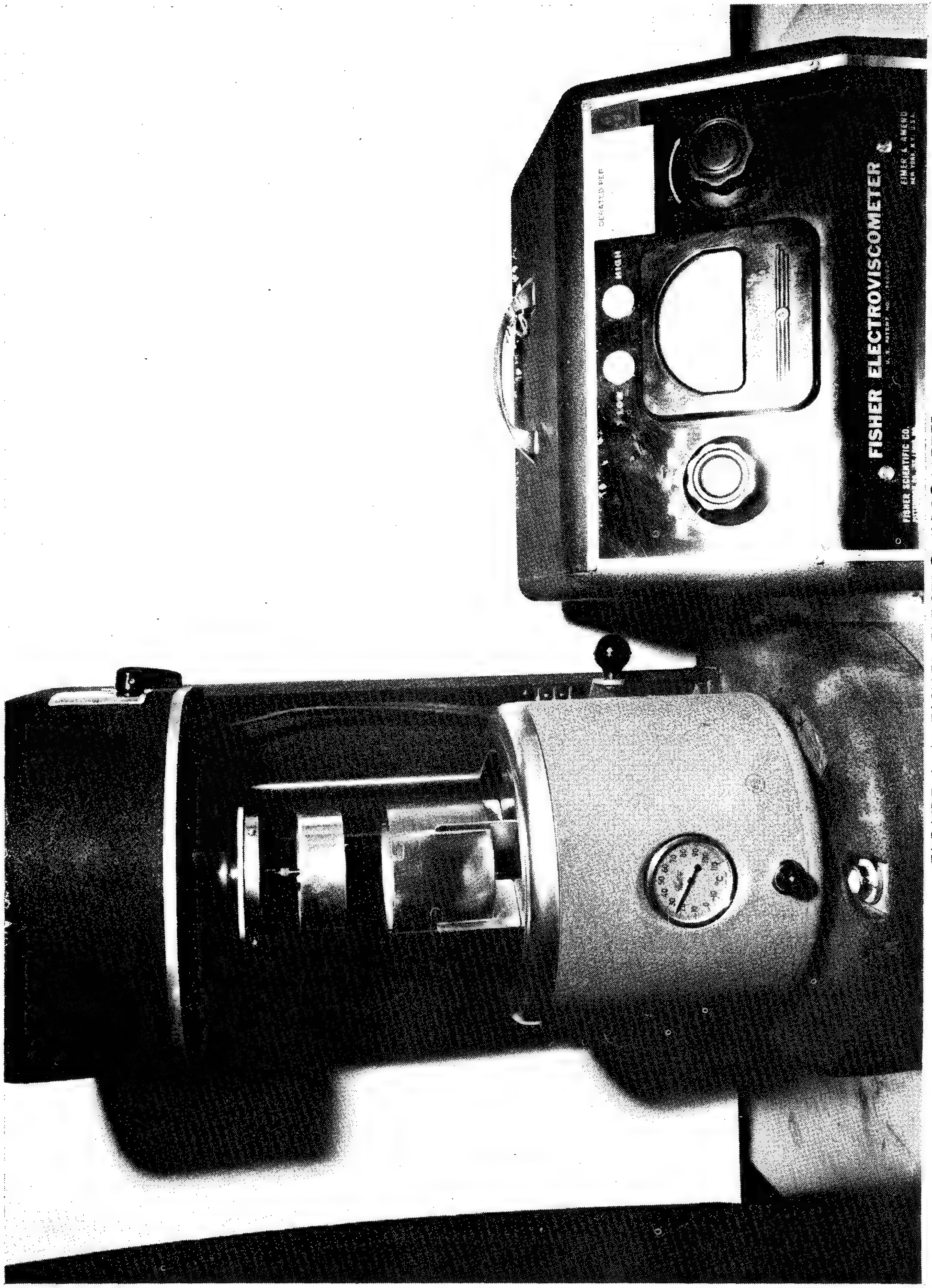


FIGURE 6-4 FISHER ELECTROVISCOMETER

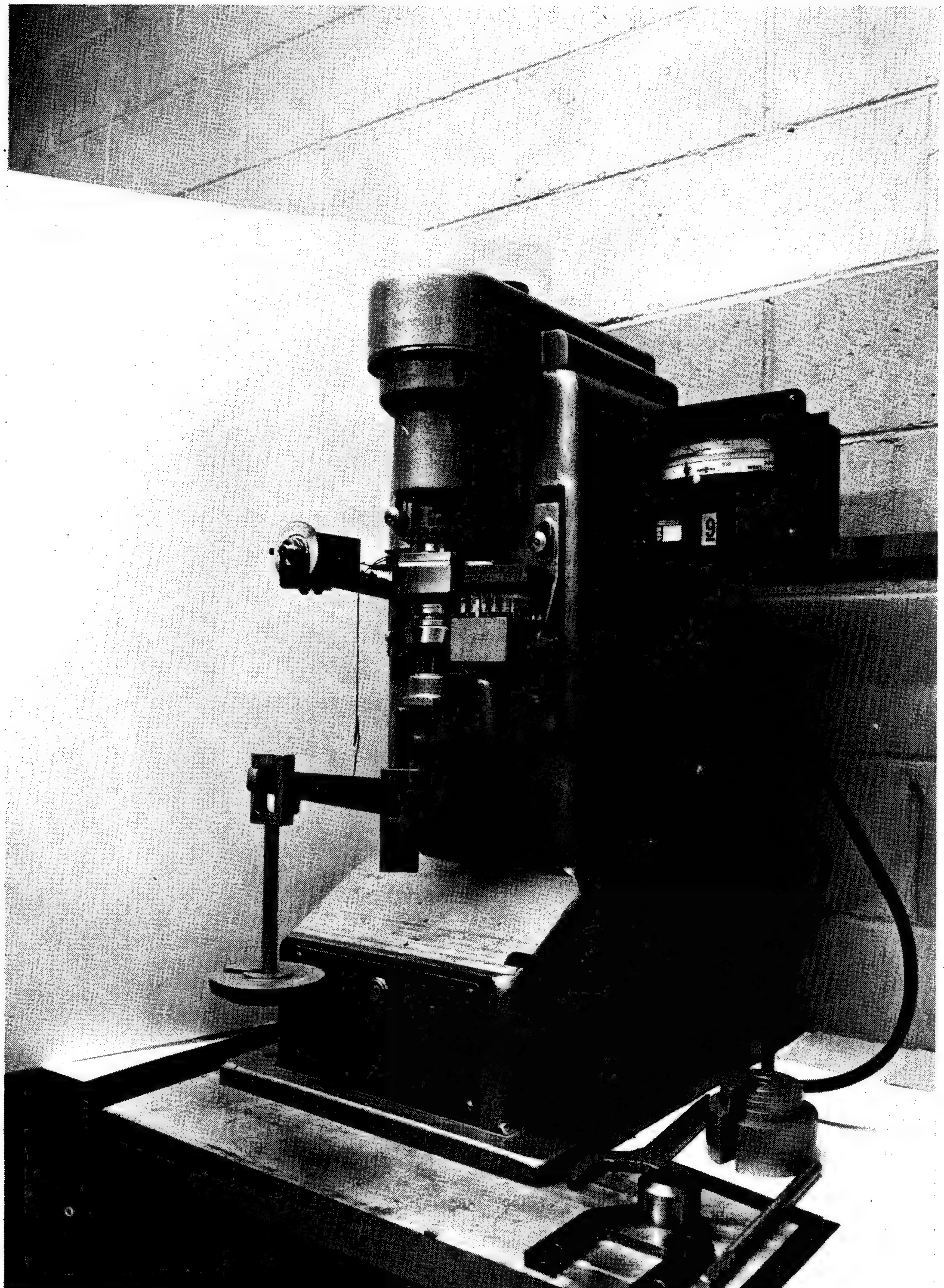


FIGURE 6-5 PRECISION - SHELL 4 - BALL WEAR TESTER

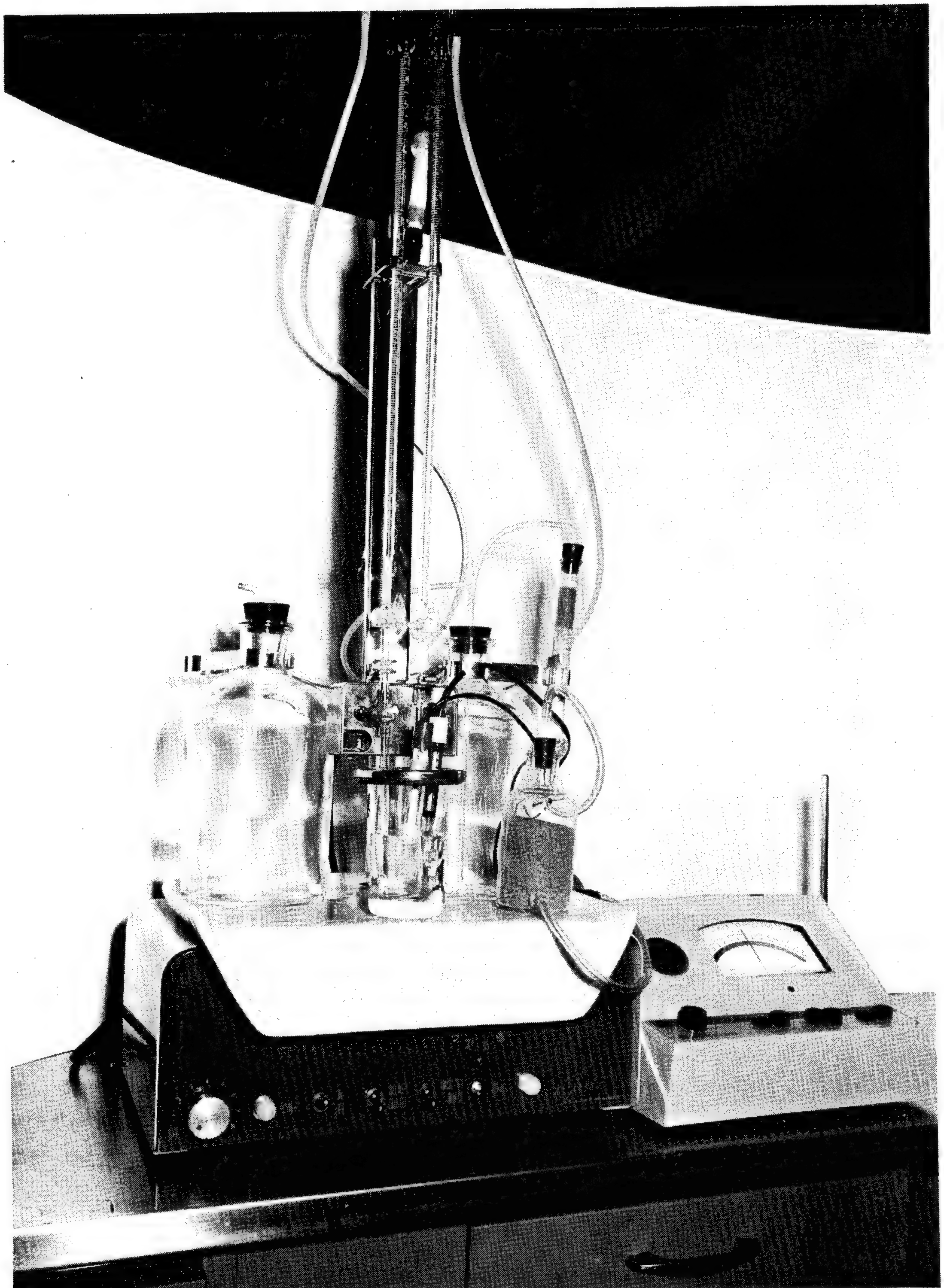


FIGURE 6-6 TOTAL ACID TITRATION ASSEMBLY

FIGURE 6-7 B & L REFRACTOMETER WITH CONSTANT TEMPERATURE BATH

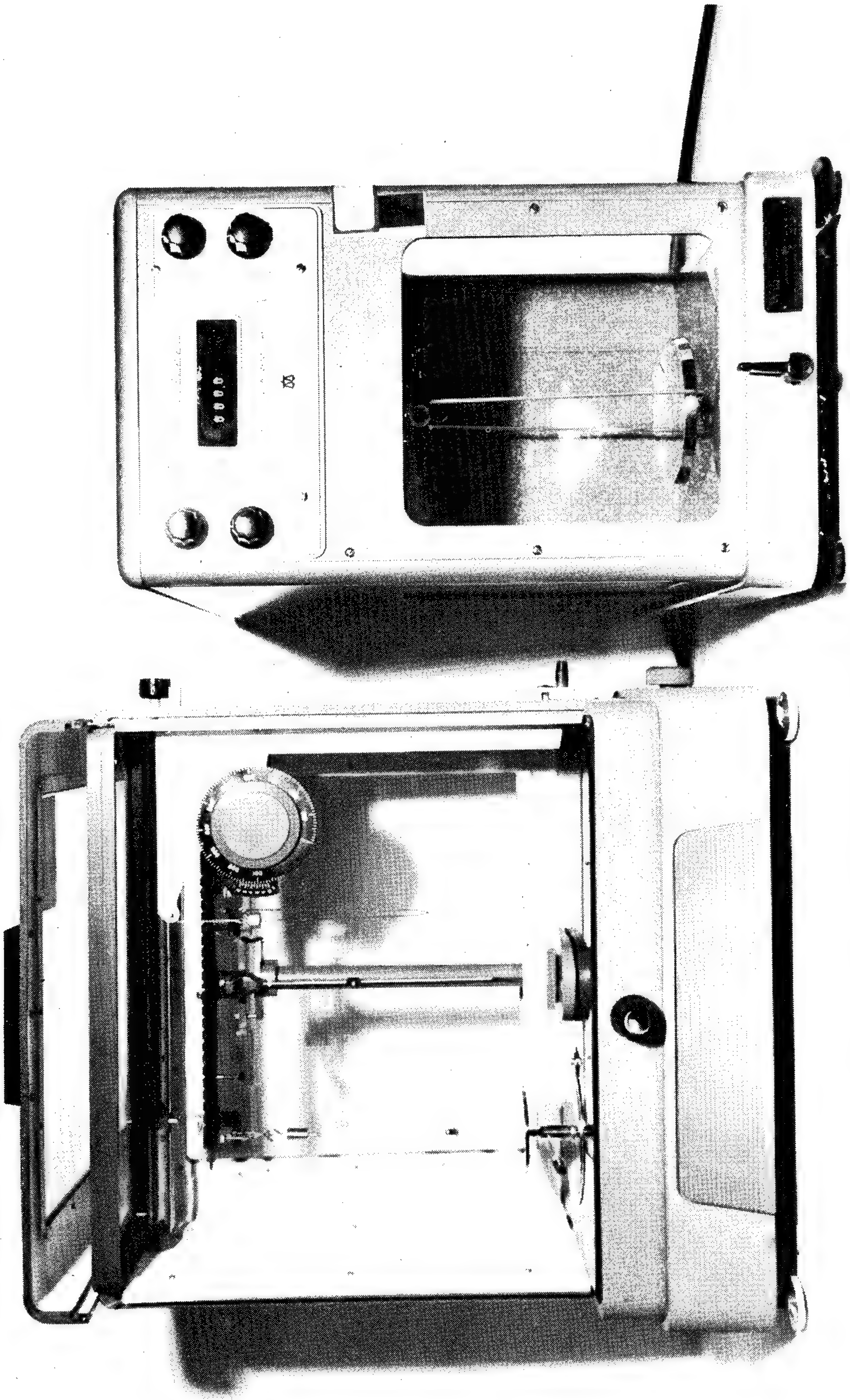


FIGURE 6-8 SPECIFIC GRAVITY AND ANALYTICAL BALANCES

FIGURE 6-9 BECKMAN IR-4 SPECTROPHOTOMETER

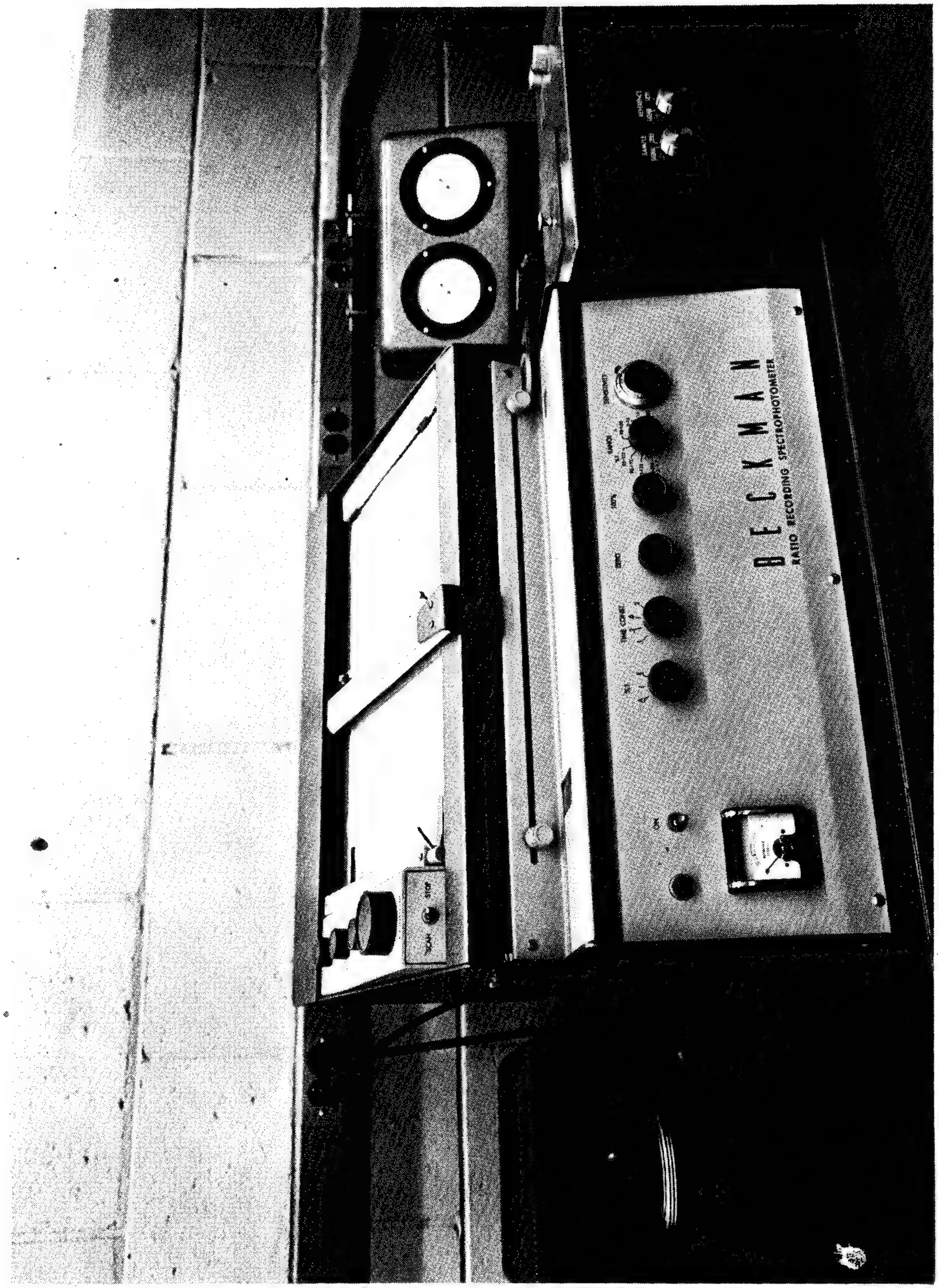


FIGURE 6-10 BECKMAN DK-2 SPECTROPHOTOMETER

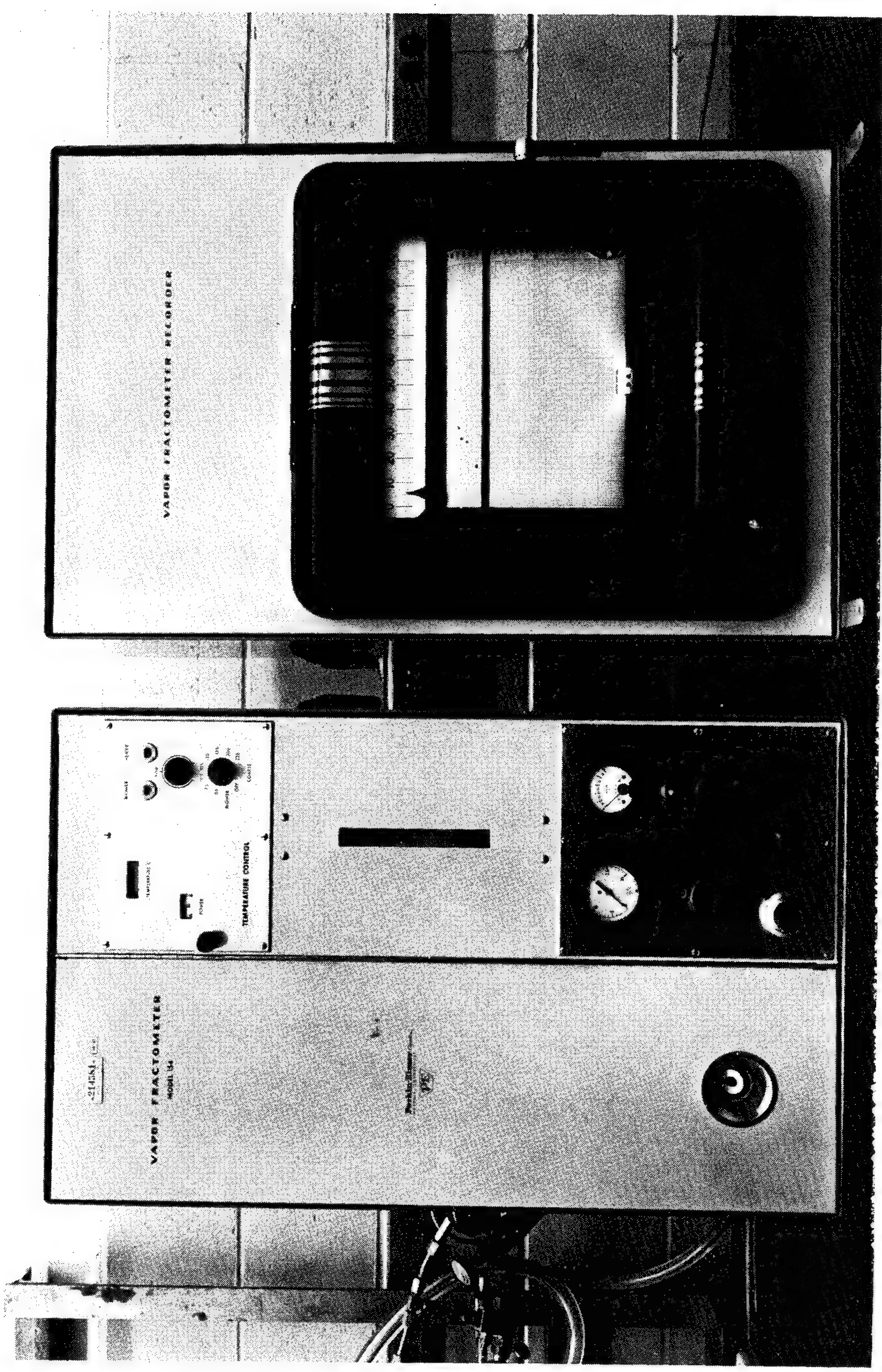


FIGURE 6-11 P & E 154 GAS CHROMATOGRAPH

TABLE 6-1
OUT-GASSING ET-378 FLUID
PRIOR TO EXPOSURE

Time hr.:min.	Pressure mm, Hg	Temperature °F	Remarks
0:00	13.4	77	
0:10	13.4	81	foaming
0:25	13.4	84	foaming
0:35	10.0	86	foaming
0:40	5.9	88	few bubbles
0:50	5.9	104	few bubbles
1:10	13.8	122	few bubbles - stirring gland leaking
1:25	13.5	135	no bubbles - stirring gland leaking
1:35	11.2	158	no bubbles - stirring gland leaking
1:40	5.5	163	no bubbles
1:45	3.0	171	no bubbles
2:00	1.5	185	no bubbles
2:05	1.3	190	no bubbles
2:15	1.3	190	heat off
2:30	1.3	185	
3:00	1.3	179	
4:00	1.3	156	vacuum off - helium in

TABLE 6-2
OUT-GASSING OS-124 FLUID
PRIOR TO EXPOSURE

Time hr.: min.	Pressure mm, Hg	Temperature °F	Remarks
0:00	2	86	heavy foaming
0:20	1.5	102	some foaming
0:30	1.3	113	some bubbles
0:35	1.3	120	increase in quantity of bubbles
0:50	1.3	143	some bubbles
1:00	1.3	169	some bubbles
1:10	1.3	176	no bubbles
1:20	1.3	179	no bubbles
1:30	1.3	181	no bubbles
1:35	1.3	183	no bubbles
1:40	1.3	185	no bubbles
1:50	1.3	183	no bubbles
2:05	1.3	181	no bubbles
2:20	1.3	181	heat off
3:20	1.3	142	
4:20	1.3	122	vacuum off - helium in

TABLE 6-3
OUT-GASSING ET-378 FLUID
AFTER VISCOSITY MEASUREMENTS

Sample	Time Min.	Temperature °F	Pressure mm, Hg	Remarks
6-1A	0:00	76	-	
	0:45	76	5	Foaming
	1:00	77	3	Foaming
	4:30	77	3	Foaming decreased
	8:00	113	2	Large amount of bubbles
	12:00	167	1.3	Bubbles
	14:20	187	1.3	Some bubbles
	15:00	189	1.3	No bubbles
	30:00	187	1.3	No bubbles
	45:00	187	1.3	No bubbles
	56:00	185	1.3	No bubbles
	60:00	185	1.2	Heat off
6-1C	0:00	76	-	
	1:00	76	6	Bubbles
	1:25	76	6	Some foaming
	2:30	77	3	Foaming
	3:00	89	3	Foaming
	10:00	95	3	Foaming
	13:30	118	2	Foaming stopped
	19:30	176	1.3	Bubbles
	21:15	185	1.3	Small Amount of bubbles
	28:00	190	1.3	No bubbles
	38:00	189	1.3	No bubbles
	57:00	190	1.3	No bubbles
	64:00	190	1.3	No bubbles; Heat off
6-1R	0:00	76	-	
	0:35	76	5	Bubbles
	1:10	76	5	Some bubbles; foaming beginning
	1:40	76	3	Foaming
	5:00	77	2	Foaming
	14:00	80	2	Foaming
	18:30	122	1.3	Foaming stopped - bubbles
	25:00	167	1.3	Large Amount of bubbles
	29:00	185	1.3	Large Amount of bubbles
	38:00	192	1.3	Amount of bubbles decreasing
	45:00	189	1.3	No bubbles
	49:00	187	1.3	No bubbles
	52:00	187	1.3	No bubbles
	57:00	187	1.3	No bubbles
	65:00	187	1.3	No bubbles; Heat off

TABLE 6-4

OUT-GASSING OS-124 FLUID

AFTER VISCOSITY MEASUREMENTS

Sample	Time Min.	Temperature °F	Pressure mm, Hg	Remarks
6-2C	0:00	76	-	
	0:35	77	8	Foaming
	1:20	77	5	Foaming
	2:00	79	3	Foaming
	3:00	81	2	Foaming
	6:00	81	2	Foaming
	12:00	81	1.8	Foaming
	15:30	81	1.3	Foaming decreased
	23:15	140	1.3	Foaming stopped; bubbles
	27:25	176	1.3	Bubbles
	28:00	185	1.3	Bubbles
	32:00	190	1.3	Small amount of bubbles
	35:30	190	1.3	Small amount of bubbles
	41:25	190	1.3	Small amount of bubbles
	55:30	189	1.3	Some bubbles; heat off
6-2R	0:00	76	-	
	0:30	76	8	Foaming
	1:45	76	6	Foaming
	3:00	76	5	Foaming
	4:00	77	4	Foaming
	8:00	77	4	Foaming
	12:00	77	2	Foaming decreased
	18:00	95	2	Large amount of bubbles
	26:45	104	1.3	Some bubbles
	37:10	124	1.3	Some bubbles
	46:15	140	1.3	Some bubbles
	57:45	158	1.3	Some bubbles
	73:00	178	1.3	Very small amount of bubbles
	79:05	185	1.3	Very small amount of bubbles
	95:00	189	1.3	Very small amount of bubbles
	105:00	190	1.3	No bubbles
	117:00	190	1.3	No bubbles
	120:00	190	1.3	No bubbles; heat off

TABLE 6-5

VISCOSITY - ET-378 FLUID

Temperature °F	Sample	Aliquote	Aliquote Average	Sample Average	Sample Minimum	Sample Maximum
100	6-1A-1	90.0 89.0 88.0 80.0	86.75	86.8	80.0	90.0
	6-1C-1	83.0 81.0 82.0	82.0	84.1	81.0	90.0
	6-1C-2	90.0 85.0 85.0 83.0 84.0	85.40			
	6-1R-1	84.0 83.0 83.0	83.33	85.2	83.0	88.0
	6-1R-2	86.0 85.0 84.0 85.0	85.00			
	6-1R-2	88.0 86.0 87.0 85.0 86.0	86.40			
210	6-1A-1	9.6 9.5 9.4 9.5	9.5	9.5	9.4	9.6
	6-1C-1	9.6 9.6	9.6	9.5	9.4	9.6
	6-1C-2	9.5 9.5 9.4	9.5			
	6-1R-1	9.6 9.5 9.6	9.6	9.7	9.5	9.8
	6-1R-2	9.8 9.8 9.8	9.8			

TABLE 6-6

VISCOSITY - OS-124 FLUID

Temperature °F	Sample	VISCOSITY - CENTIPOISES Aliquote	Aliquote Average	Sample Average	Sample Minimum	Sample Maximum
100	6-2C-1	420 425 420	421.6	421	415	425
	6-2C-2	415 418	416.5			
	6-2C-3	423 425 418	422.0			
	6-2R-1	465 458 460	461.0	454	445	465
	6-2R-2	449 450 455 450	451.0			
	6-2R-3	455 445 450 455 455	452.0			
210	6-2C-1	17.8 17.5 17.8	17.70	18.0	17.5	18.3
	6-2C-2	18.3 18.1 18.2	18.20			
	6-2C-3	18.2 18.0 18.2 18.1	18.12			
	6-2R-1	19.3 18.4 18.8 19.9	18.85	18.9	18.4	19.3
	6-2R-2	19.0 18.9 18.8	18.90			
	6-2R-3	18.8 18.9 19.0 18.7	18.85			

TABLE 6-7
4-BALL WEAR TEST - ET-378 FLUID

Sample	Test Load Kg	SCAR DIAMETER, MILLIMETERS "A" Direction	"A" Direction Average	"B" Direction	"B" Direction Average	Sample Average	Sample Min.	Sample Max.	COEFFICIENT OF FRICTION At Start of Test	At Middle of Test	At End of Test
6-1A1	10	0.730 0.765 0.768	0.75	0.792 0.830 0.812	0.81	0.80	0.730	0.830	0.215	0.153	0.233
6-1A2		0.802 0.815 0.755	0.79	0.818 0.850 0.790	0.82				< 0.085	0.178	0.212
6-1A3		0.808 1.025* 0.755	0.78	0.865 1.025* 0.776	0.82				0.240	0.190	0.190
6-1C1		0.802 0.922 0.848	0.86	0.835 0.948 0.870	0.88	0.80	0.698	0.948	0.174	0.214	0.219
6-1C2		0.710 0.698 0.709	0.71	0.775 0.752 0.745	0.76				0.185	< 0.085	< 0.085
6-1R1		0.862 0.878 0.855	0.86	0.896 0.932 0.912	0.91	0.79	0.635	0.932	< 0.085	< 0.085	< 0.085
6-1R2		0.662 0.705 0.635	0.67	0.705 0.755 0.686	0.72				< 0.085	--	< 0.08
6-1A4	50	1.210 1.230 1.245	1.23	1.195 1.218 1.235	1.22	1.16	1.082	1.245	> 0.081	--	> 0.081
6-1A5		1.138 1.085 1.125	1.15	1.122 1.082 1.096	1.10				> 0.081	--	> 0.081
6-1C3		1.284 1.160 1.185	1.21	1.315 1.214 1.215	1.25	1.12	0.982	1.315	> 0.081	--	> 0.081
6-1C4		0.982 1.009 1.002	1.00	1.020 1.038 1.028	1.03				> 0.081	--	> 0.081
6-1R4		1.132 1.095 1.086	1.10	1.160 1.125 1.090	1.12	1.08	0.972	1.160	> 0.081	--	> 0.081
6-1R5		0.972 1.008 0.978	0.99	1.122 1.082 1.096	1.10				> 0.081	--	> 0.081

* Showed signs of seizure; not included in average
"A" Direction: Diameter with direction of rotation of center ball
"B" Direction: Diameter at right angles to direction of rotation of center ball
Test Conditions: Temperature: 392° F
RPM : 600
Test Balls : 1/2 in. dia., ATLAS EP, Grade 1 Steel Balls

TABLE 6-8

4-BALL WEAR TEST

SAE-30 MOTOR OIL AND MIL-L-7808 OIL

Sample	Test Load Kg	SCAR DIAMETER, MILLIMETERS "A" Direction	"A" Average	"B" Direction	"B" Average	Sample Average	Sample Min.	Sample Max.	COEFFICIENT OF FRICTION At Start of Test	At Middle of Test	At End of Test
Rotella, Oil, SAE-30 Heavy Duty Shell Oil Co. Drum No	50	0.39 0.39 0.36		0.37 0.36 0.37		0.38	0.36	0.39	> 0.08	> 0.08	> 0.08
		0.39 0.38 0.39		0.38 0.37 0.38							
Mil-L-7808E (9150-270-0056) Royal Lub. Co	10	0.89 0.86 0.86	0.87	0.87 0.86 0.86	0.86	0.83	0.78	0.89	< 0.085	< 0.085	< 0.085
		0.78 0.82 0.79	0.80	0.78 0.79 0.81	0.79						
DSA-6-4075 Qual-11C Lot-72 Nov.62	50	1.18 1.19 1.16	1.18	1.19 1.19 1.17	1.18	1.14	1.01	1.23	> 0.08	> 0.08	> 0.08
		1.04 1.02 1.02	1.02	1.02 1.01 1.01	1.01						
		1.22 1.23 1.23	1.23	1.19 1.21 1.21	1.20						

Test Conditions: Temperature: 392° F
RPM: 600
Test Balls: 1/2 in. dia., Atlas EP, Grade 1 Steel Balls

"A" Direction: Diameter with direction of rotation of center ball
"B" Direction: Diameter at right angles to direction of rotation of center ball

TABLE 6-9

4-BALL WEAR TEST
OS-124 FLUID

Sample	Test Load Kg	SCAR DIAMETER, MILLIMETERS "A" Direction		"B" Direction		Sample Average	Sample Min.	Sample Max.	COEFFICIENT OF FRICTION At Start of Test	At Middle of Test	At End of Test
			Average		Average						
6-2C1	10	0.730 0.846 0.808	0.79	0.752 0.886 0.850	0.83	0.77	0.676	0.886	0.085	0.190	0.217
6-2C2		0.676 0.688 0.714	0.69	0.745 0.748 0.762	0.75				0.180	0.179	0.178
6-2R1		0.705 0.626 0.660	0.66	0.721 0.660 0.703	0.69	0.74	0.626	0.823	0.171	--	< 0.085
6-2R2		0.800 0.760 0.780	0.78	0.832 0.790 0.808	0.81				0.085	--	< 0.085
6-2C3	50	0.830 0.830 0.810	0.82	0.940 0.925 0.915	0.93	0.94	0.810	1.040	> 0.081	--	> 0.081
6-2C4		0.980 1.010 0.985	0.99	1.000 1.040 1.030	1.02				> 0.081	--	> 0.081
6-2R3		0.880 0.900 0.920	0.90	0.980 0.980 1.000	0.99	0.97	0.880	1.040	> 0.081	--	> 0.081
6-2R4		0.965 0.960 0.950	0.96	1.040 1.020 1.005	1.02				> 0.081	--	> 0.081

"A" Direction: Diameter with direction of rotation of center ball
"B" Direction: Diameter at right angles to direction of rotation of center ball
Test Condition: Temperature: 392° F
RPM: 600
Test Balls: 1/2 in. dia. Atlas EP, Grade 1 Steel Balls, 52100 steel

TABLE 6-10

TOTAL ACID, ET-378 FLUID

Sample		TOTAL ACID, MG KOH PER GRAM SAMPLE			
		Aliquote	Sample Average	Sample Min.	Sample Max.
6-1A	-1 -2 -3	0.04467 0.04581 0.03365	0.041	0.03365	0.04581
6-1C	-1 -2 -3	0.03793 0.03318 0.03247	0.035	0.03247	0.03793
6-1R	-1 -2 -3	0.03458 0.03571 0.03687	0.036	0.03458	0.03687

TABLE 6-11

TOTAL ACID, OS-124 FLUID

Sample		TOTAL ACID, MG KOH PER GRAM SAMPLE			
		Aliquote	Sample Average	Sample Min.	Sample Max.
6-2C-2	-1 -2 -3	0.03819 0.04774 0.04109	0.042	0.03819	0.04774
6-2R	-1 -2 -3 -4 -5 -6 -7	0.09734 0.08141 0.13385 0.15542 0.12128 0.14334 0.12834	0.123	0.08141	0.15542

TABLE 6-12
REFRACTIVE INDEX
ET-378 FLUID
TEMPERATURE, 77° F

Fluid	Sample	SCALE READING		Refractive Index	Average Refractive Index
		L Direction	R Direction		
ET-378	6-1A1 6-1A2	422.0 --	-- 422.0	1.62891 1.62891	1.6289
	6-1C1 6-1C2	422.3 --	-- 422.2	1.62902 1.62898	1.6290
	6-1R1 6-1R2 6-1R3	423.4 -- 423.3	-- 423.4 --	1.62943 1.62943 1.62939	1.6294

TABLE 6-13
REFRACTIVE INDEX
OS-124 FLUID
TEMPERATURE, 77° F

Fluid	Sample	SCALE READING L Direction	SCALE READING R Direction	Refractive Index	Average Refractive Index
OS-124	6-2A1	445.4	--	1.63018	1.6302
	6-2A2	--	445.4	1.63018	
	6-2C1	445.3	--	1.63014	1.6302
	6-2C2	--	445.4	1.63018	
	6-2R1	446.7	--	1.63066	1.6307
	6-2R2	--	446.8	1.63070	
	6-2R3	446.8	--	1.63070	

TABLE 6-14
SPECIFIC GRAVITY
ET-378 FLUID

Sample	Temperature °F	Specific Gravity
6-1A	76	1.175
6-1C	76	1.175
6-1R	76	1.175

TABLE 6-15
SPECIFIC GRAVITY
OS-124 FLUID

Sample	Temperature °F	Specific Gravity
6-2C	76	1.197
6-2R	76	1.197

TABLE 6-16
ET-378 OFF GAS ANALYSIS

SAMPLE			HELIUM		COLUMN		MOLE PERCENT			
Number	Pressure In. Hg	Volume ml	Flow cc/Min.	Pressure Psig	Temp. °F	Type	H_2	O_2 *	N_2 *	CH_4
6-1R-1	19.18	5	60	7.5	122°	Molecular Sieve-5A, Length, 2 Meters	47.3	1.6	29.2	21.8
							68.5**	-	-	31.5**
6-1R-2							33.3	1.6	38.5	26.5
							55.7**	-	-	44.3**
6-1R-3							~20.7	~0.5	~60.6	~ 9.3
							69.0**	-	-	31.0**
AVERAGE							64.4			35.6

NOTE: * O_2 and N_2 due to leak in gas chromatograph vacuum manifold

** O_2 and N_2 not considered in calculations

TABLE 6-17
OS-124 OFF GAS ANALYSIS

SAMPLE			HELIUM		COLUMN		MOLE PERCENT				
Number	Pressure In. Hg	Volume ml	Flow cc/Min.	Pressure Psig	Temperature °F	Type	H_2	O_2*	N_2*	CH_4	CO
6-2R-1	19.10	5	60	7.5	122	Molecular Sieve-5A	36.1	11.3	42.5	1.1	9.1
							78.1**	-	-	2.3**	19.6**
6-2R-2	19.15				~ 72	Length 2 Meters	79.1**	-	-	1.8**	19.1**
6-2R-3							68.8**	-	-	2.5	28.7**
6-2R-4				7.25			77.3**	-	-	1.7**	21.1**
Average							75.8			2.1	22.1

NOTE: * O_2 and N_2 due to leak in gas chromatograph vacuum manifold.

** O_2 and N_2 not considered in calculations.

TABLE 6-18
ELECTRICAL PROPERTIES
ORGANIC FLUIDS

Specimen Inentification	CONTROL -			IRRADIATED -		
	Dielectric Constant	Volume Resistivity OHM-CM	Dissipation Factor Percent	Dielectric Constant	Volume Resistivity OHM-CM	Dissipation Factor Percent
VI-1 ET-378 Mixed (Bis(Phenoxyphenyl)Ether) Dow Chemical	4.47	1.2×10^{12}	< 0.00001	4.50	2.1×10^{10}	0.00179
VI-2 OS-124 Mixed (Bix(Phenoxy-Phenoxy)Benzene) Monsanto Chemical Co.	4.52	~ 4.0×10^{13}	< 0.00001	4.60	4.4×10^{10}	0.00823

7.0 TEST SPECIMENS

GROUP VII GLASS LAMINATE

VII-1 Silicone glass laminate, Product No. 11556, General Electric Co.

VII-2 Diphenyl oxide glass laminate product. Micarta H-17511, Westinghouse Co.

7.1 PROCEDURE

The procedures as outlined in ND-5001, Revised 27 April 1964, were followed.

7.2 NUCLEAR ENVIRONMENT

Material	NEUTRON FLUX Rate $n/cm^2/sec$	NEUTRON FLUX Integrated n/cm	GAMMA DOSE Rate Rads/ Hr	GAMMA DOSE Integrated Rads
1	1.0×10^8	5.0×10^{13}	7.5×10^5	1.0×10^8
2	7.3×10^7	3.6×10^{13}	6.4×10^5	8.8×10^7

7.3 RESULTS

7.3.1 Visual

All specimens changed to a slightly darker color (See Table 7-1).

7.3.2 Thickness Change

All specimens showed a slight change ($< \pm 0.5$ mils) in thickness. A change which is significant for most applications (See Tables 7-2 and 7-3).

7.3.3 Weight Change

All specimens showed a slight change ($< 1.0\%$) in weight; however, the effect of temperature and radiation appear to be insignificant (See Tables 7-4 and 7-5).

7.3.4 Flexural Strength

Equipment used in the flexural strength tests is shown in Figures 3-1 and 3-2.

7.3.4.1 VII-1 Material

There was a significant decrease in the flexural strength of this material due to temperature (-9%) and a large change due to temperature and radiation (-49%). See Table 7-6.

7.3.4.2 VII-2 Material

There was no significant effect due to temperature and radiation (See Table 7-7).

TABLE 7-1

COLOR CHANGE, VII-1 AND -2

MATERIAL AND SPECIMEN NUMBER	APPARENT COLOR CHANGE
1C7-12 1-R13-18	Light Cream Color Slightly Darker
2-C7-12 2-R13-18	Dark Brown Color Darkened Slightly

TABLE 7-2

THICKNESS CHANGE, VII-1

Specimen Number	BEFORE EXPOSURE THICKNESS, MILS						BEFORE EXPOSURE	AFTER EXPOSURE THICKNESS, MILS						AFTER EXPOSURE	AVERAGE THICKNESS CHANGE	
	Pt. 1	Pt. 2	Pt. 3	Pt. 4	Pt. 5	Pt. 6	Average mils	Pt. 1	Pt. 2	Pt. 3	Pt. 4	Pt. 5	Pt. 6	Average mils	mils	Percent
C-7	30.0	30.0	30.3	30.1	30.7	30.7	30.3	30.0	30.0	30.1	30.2	30.4	30.5	30.2	-0.1	-0.33
C-8	31.4	31.6	31.6	31.6	31.6	31.6	31.6	31.3	31.2	31.0	31.0	31.3	31.0	31.1	-0.5	-1.58
C-9	31.5	31.5	31.5	31.5	31.5	31.5	31.5	31.5	31.5	31.5	31.5	31.6	31.5	31.5	0.0	0.00
C-10	28.6	28.6	28.7	29.0	29.0	29.5	28.9	29.7	29.7	29.0	28.9	28.9	29.0	29.2	+0.3	+1.04
C-11	31.6	31.6	31.6	31.7	31.6	31.6	31.6	31.5	31.5	31.7	31.7	31.6	31.5	31.6	0.0	0.00
C-12	31.9	31.9	32.0	31.8	31.8	31.9	31.9	31.8	31.8	31.7	31.8	31.6	31.8	31.8	-0.1	-0.31
AVERAGE (RANGE)															-0.07 (-0.5; +0.3)	-0.36 (-1.58; +1.04)
R-13	31.9	32.0	32.3	32.5	32.3	32.5	32.3	32.0	32.1	32.6	32.7	32.2	32.3	32.3	0.0	0.00
R-14	32.1	32.2	32.2	32.4	31.6	32.0	32.1	32.4	32.3	32.2	32.2	32.0	31.8	32.2	+0.1	+0.31
R-15	32.5	32.0	32.0	31.9	31.8	31.9	32.0	31.5	31.7	32.0	31.8	31.9	31.9	31.9	-0.1	-0.31
R-16	31.7	31.6	31.6	31.7	31.7	31.7	31.7	32.0	32.0	32.0	31.9	32.0	32.0	32.0	+0.3	+0.95
R-17	31.7	31.7	31.9	32.0	32.1	32.1	31.9	31.9	32.0	32.0	31.9	31.8	31.5	31.9	0.0	0.00
R-18	30.5	30.3	30.2	30.2	30.2	30.2	30.3	30.0	30.3	30.3	30.4	30.3	30.2	30.3	0.0	0.00
AVERAGE (RANGE)															+0.05 (-0.1; +0.3)	+0.16 (-0.31; +0.95)

NOTE: A thickness change greater than ± 0.5 mils is considered to be significant

TABLE 7-3

THICKNESS CHANGE, VII-2

Specimen Number	BEFORE EXPOSURE THICKNESS, MILS Pt. 1	Pt. 2	Pt. 3	Pt. 4	Pt. 5	Pt. 6	Average mils	AFTER EXPOSURE THICKNESS, MILS Pt. 1	Pt. 2	Pt. 3	Pt. 4	Pt. 5	Pt. 6	Average mils	AVERAGE THICKNESS CHANGE mils	Percent
C-7	40.7	40.5	40.2	39.5	39.0	38.0	39.7	37.7	39.0	39.5	40.3	40.6	40.7	40.0	+0.3	+0.76
C-8	37.7	37.5	37.3	37.0	36.4	36.8	37.1	36.5	36.5	36.8	37.2	37.4	37.5	37.5	-0.1	-0.27
C-9	42.0	42.0	41.7	41.5	41.5	41.5	41.7	41.5	41.5	41.5	41.7	41.5	41.7	41.6	-0.1	-0.24
C-10	41.6	41.5	41.4	41.4	41.4	41.4	41.4	41.5	41.5	41.5	41.4	41.4	41.5	41.5	+0.1	+0.24
C-11	41.4	41.5	41.5	41.7	42.0	41.6	41.6	41.3	41.5	41.5	41.6	41.7	41.9	41.6	0.0	0.00
C-12	40.6	40.5	40.6	40.7	40.6	40.5	40.6	40.3	41.0	40.3	40.6	40.3	40.5	40.5	-0.1	-0.25
AVERAGE															+0.05	+0.04
(RANGE)															(-.1; +0.3)	(-0.27; +0.76)
R-13	38.5	38.5	40.2	39.0	39.2	39.8	39.2	39.6	39.4	39.0	39.0	38.5	38.0	38.9	-0.3	-0.76
R-14	41.5	41.3	41.2	41.0	41.0	40.7	41.1	41.6	41.4	41.2	41.0	40.8	40.6	41.1	0.0	0.00
R-15	38.6	38.5	38.5	38.0	37.9	38.0	38.3	38.5	38.5	38.3	38.0	37.9	38.0	38.2	-0.1	-0.26
R-16	40.0	40.0	40.1	40.0	40.0	40.2	40.0	40.0	40.0	40.1	39.8	39.7	39.8	39.9	-0.1	-0.25
R-17	40.0	39.8	39.9	39.7	39.5	39.7	39.7	39.4	40.0	39.5	39.5	40.0	40.3	39.8	+0.1	+0.25
R-18	40.0	40.6	40.5	40.3	40.4	40.5	40.5	40.5	40.4	40.5	40.5	40.5	40.5	40.5	0.0	0.00
AVERAGE															-0.1	-0.17
(RANGE)															(-0.3; + 0.1)	(-0.76; +0.25)

NOTE: A thickness change greater than $\pm$ 0.5 mils is considered to be significant

TABLE 7-4

WEIGHT CHANGE

VII-1

Specimen Number	WEIGHT, GRAMS Before Exposure	After Exposure	WEIGHT CHANGE Grams	Percent	AVERAGE Grams	Percent
C7	2.1974	2.1970	-0.0004	-0.02		
C8	2.2290	2.2290	0.0000	0.00		
C9	2.1839	2.1836	-0.0003	-0.01	-0.0003	-0.02
C10	2.1609	2.1604	-0.0005	-0.02	(-0.0005;	(-0.023;
C11	2.2454	2.2451	-0.0003	-0.01	0.0000)	0.000)
C12	2.2642	2.2637	-0.0005	-0.02		
R13	2.2231	2.2208	-0.0023	-0.10		
R14	2.2575	2.2555	-0.0020	-0.09		
R15	2.2528	2.2496	-0.0032	-0.14	-0.0027	-0.12
R16	2.3050	2.3016	-0.0034	-0.15	(-0.0034;	(-0.142;
R17	2.2323	2.2292	-0.0031	-0.14	-0.0020)	-0.089)
R 18	2.1613	2.1592	-0.0021	-0.10		

NOTE: A weight change greater than ± 1.0% is considered to be significant

TABLE 7-5

WEIGHT CHANGE

VII-2

Specimen Number	WEIGHT, GRAMS Before Exposure	After Exposure	WEIGHT CHANGE Grams	Percent	AVERAGE Grams	Percent
C7	2.9543	2.9461	-0.0082	-0.28		
C8	2.7490	2.7413	-0.0072	-0.28		
C9	2.9231	2.9155	-0.0076	-0.26	-0.0081	-0.28
C10	2.9402	2.9319	-0.0083	-0.28	(-0.0086;	(-0.29;
C11	2.9883	2.9797	-0.0086	-0.29	-0.0072)	-0.26)
C12	3.0476	3.0388	-0.0088	-0.29		
R13	2.7431	2.7499	-0.0032	-0.12		
R14	3.0417	3.0379	-0.0038	-0.12		
R15	2.7980	2.7945	-0.0035	-0.13	-0.0035	-0.12
R16	2.9163	2.9128	-0.0035	-0.12	(-0.0038:	(-0.13;
R17	2.8585	2.8551	-0.0034	-0.12	-0.0032)	-0.12)
R18	3.1570	3.1533	-0.0037	-0.12		

NOTE: A weight change greater than ± 1.0% is considered to be significant

TABLE 7-6

FLEXURAL STRENGTH, VII-1

Specimen Number	FLEXURAL STRENGTH, psi			
	psi	Average	Minimum	Maximum
-A1	46,600			
-A2	40,500			
-A3	43,500	43,200	39,800	46,600
-A4	47,700			
-A5	39,800			
-A6	41,300			
-C7	40,100			
-C8	38,100			
-C9	38,400	39,300	35,600	45,900
-C10	45,900			
-C11	35,600			
-C12	37,900			
-R13	21,400			
-R14	19,800			
-R15	19,000	21,000	19,000	26,200
-R16	19,900			
-R17	19,900			
-R18	26,200			

TABLE 7-7

FLEXURAL STRENGTH, VII-2

Specimen Number	FLEXURAL STRENGTH, psi			
	psi	Average	Minimum	Maximum
-A1	73,200			
-A2	69,100			
-A3	71,100	71,800	69,100	75,500
-A4	70,900			
-A5	70,900			
-A6	75,500			
-C7	88,800*			
-C8	73,700			
-C9	81,400*	72,300	69,300	73,800
-C10	79,800*			
-C11	69,300			
-C12	73,800			
-R13	87,800*			
-R14	73,700			
-R15	75,300	73,000	70,300	75,300
-R16	72,100			
-R17	73,600			
-R18	70,300			

* Orientation of surface fibers approximate contact angle of 77 degrees; values not included in average

8.0 TEST SPECIMENS

GROUP VIII ORGANIC CUBES

VIII-1 Novalak Epoxy, AGC Type 1, Spec. No. A50DC241A, General Electric Co.

VIII-2 Bisphenyl A. Epoxy, AGC Type 2, General Electric Co.

VIII-3 Sylgard 183, AGC Type 13 Encapsulant, Dow Corning Co.

VIII-4 Epocast 17B Furane Plastics, AGC Type 9 Encapsulant.

VIII-5 CF-8794, Westinghouse, AGC Type 7 Encapsulant.

VIII-6 CF-8793, Westinghouse AGC Type 6 Encapsulant.

8.1 PROCEDURE

The procedures as outlined in the Experimental Design Manual ND-5001, Revised 27 April 1964, were followed with the following exception.

8.1.1 Dielectric Strength

In addition to the ac dielectric test outlined in the design manual the specimens were subjected to a dc test with the test equipment having a voltage capability of 100 kV.

8.2 NUCLEAR ENVIRONMENT

Material	NEUTRON FLUX Rate $n/cm^2/sec$	NEUTRON FLUX Integrated n/cm	GAMMA DOSE Rate Rads/hr	GAMMA DOSE Integrated Rads
1	8.0×10^7	4.0×10^{13}	6.4×10^5	8.8×10^7
2	7.3×10^7	3.6×10^{13}	6.4×10^5	8.8×10^7
3	7.5×10^7	3.7×10^{13}	6.8×10^5	9.4×10^7
4	8.1×10^7	4.0×10^{13}	6.4×10^5	8.8×10^7
5	8.7×10^7	4.3×10^{13}	7.3×10^5	1.0×10^8
6	7.3×10^7	3.8×10^{13}	6.8×10^5	9.4×10^7

8.3 RESULTS

8.3.1 Visual

8.3.1.1 VIII-1 and VIII-3 Materials

No color changes apparent in these materials.

8.3.1.2 VIII-2, VIII-4, VIII-5, and VIII-6 Materials

All specimens of these materials showed some color change with the irradiated specimens being the darker (See Table 8-1).

8.3.2 Weight Change

8.3.2.1 VIII-1, VIII-2, VIII-4, VIII-5 and VIII-6 Materials

All specimens showed a slight loss after test; the greatest change occurring in the irradiated specimens. In general, there was little change in the weight of the specimens with time after the irradiation. (See Tables 8-2, 8-3, 8-5, 8-6, and 8-7.)

8.3.2.2 VIII-3 Material

All specimens showed a weight loss after test. However, after the "1st weighing," the Control 392° F specimens gained weight and the Irradiated specimens lost weight (See Table 8-4).

8.3.3 Insulation Resistance

The results of the insulation resistance measurements for the organic cubes are shown in Tables 8-8, 8-9, 8-10, 8-11, 8-12, and 8-13. The data shows a downward trend in the insulation resistance between the pre- and post-measurements of the control group. However, the scatter of data for pre- and post-irradiation measurements does not permit conclusions to be drawn other than, no significant radiation damage occurred. The test configuration is shown in Figure 8-1.

8.3.4 Dielectric Constant

The calculation of dielectric constants were not made since the geometry prohibited the calculation to any reasonable accuracy. Comparison of capacitance measurements are shown in Tables 8-8, 8-9, 8-10, 8-11, 8-12, and 8-13. The changes in the capacitance values appear to be of little significance with the exception of those changes exhibited in Group VIII-3. There appears to be significant changes in this group; however, no definite conclusions should be drawn defining temperature and radiation effects because the values of the capacitance measures in Group VIII-3 was on the order of 0.4 to 0.8 picafarads. With these very small capacities the repeatability of the measurements could account for these apparent changes.

8.3.5 Dissipation Factor

8.3.5.1 Group VIII-1

The results of the dissipation factor measurements are shown in Table 8-8. There appears to be significant changes in both the control specimens and the irradiated

specimens. These changes seem to be due to temperature only. The test configuration is shown in Figure 8-2.

8.3.5.2 Group VIII-2

The results of the dissipation factor measurements are shown in Table 8-9. There appears to be significant changes in both the control and irradiated specimens. There was approximately a 50% increase in dissipation in the control specimens, and more than a 100% change was observed in the irradiated specimens. Both temperature and radiation have detrimental effects on the material with radiation adding to the effects due to temperature.

8.3.5.3 Group VIII-3

The results of the dissipation factor measurements are shown in Table 8-10. In this group even though there appears to be significant changes, no definite conclusions should be drawn as to radiation effects. The comments stated in 8.3.4 about the apparent changes in dielectric constant also apply to the dissipation factor values.

8.3.5.4 Group VIII-4

The results of the dissipation factor measurements are shown in Table 8-11. Changes were noticed in the pre- and post-test and appear to be similar to the effects of those specimens in Group VIII-2.

8.3.5.5 Group VIII-5

The results of the dissipation factor measurements are shown in Table 8-13. A similar condition exists in this group as was pointed out in Group VIII-4.

8.3.5.6 Group VIII-6

The results of the dissipation factor measurements are shown in Table 8-13. The

very small differences between the pre- and post-measurements are insufficient to conclude the presence of temperature or radiation effects.

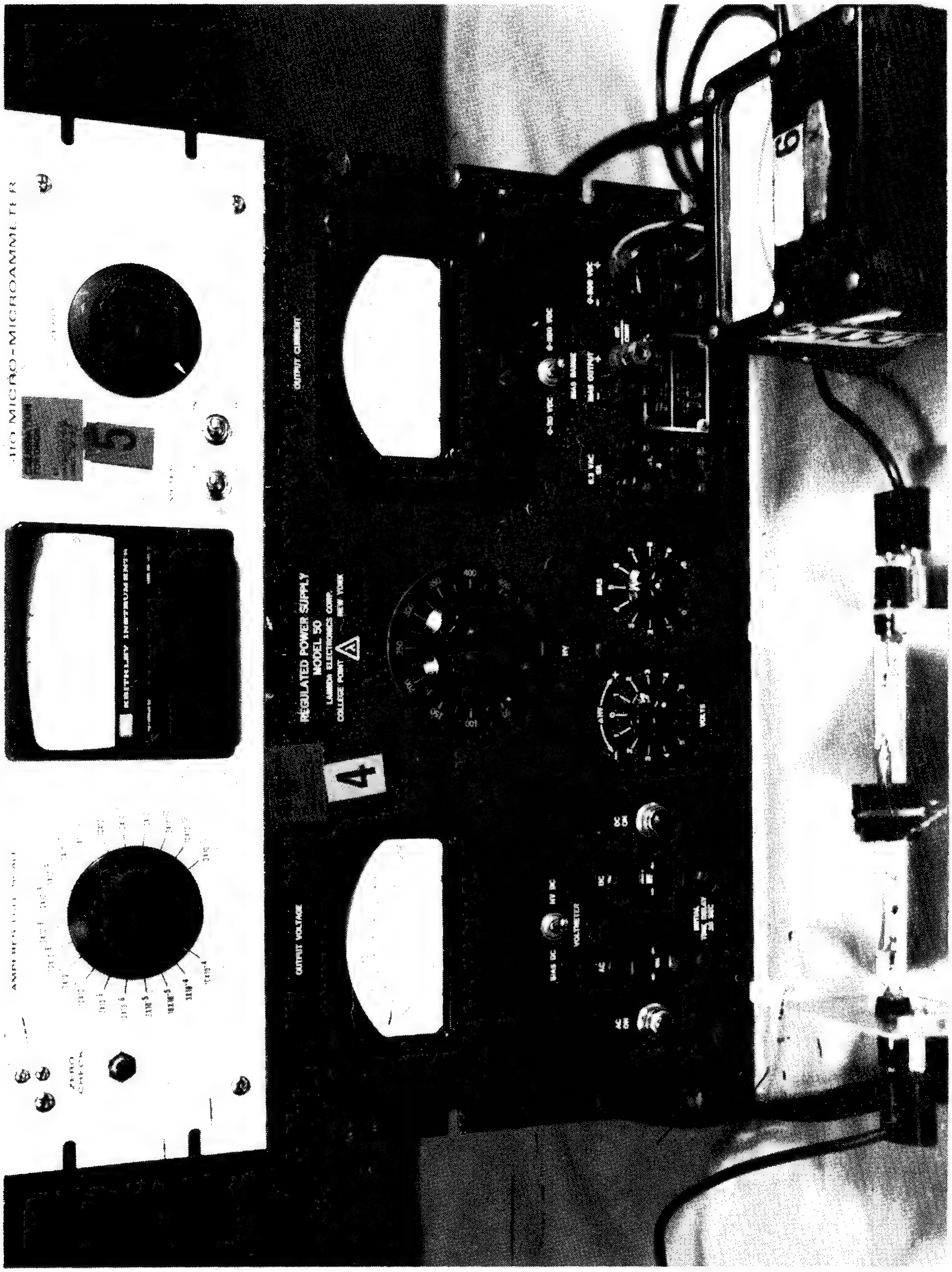


FIGURE 8-1 INSULATION RESISTANCE TEST SETUP

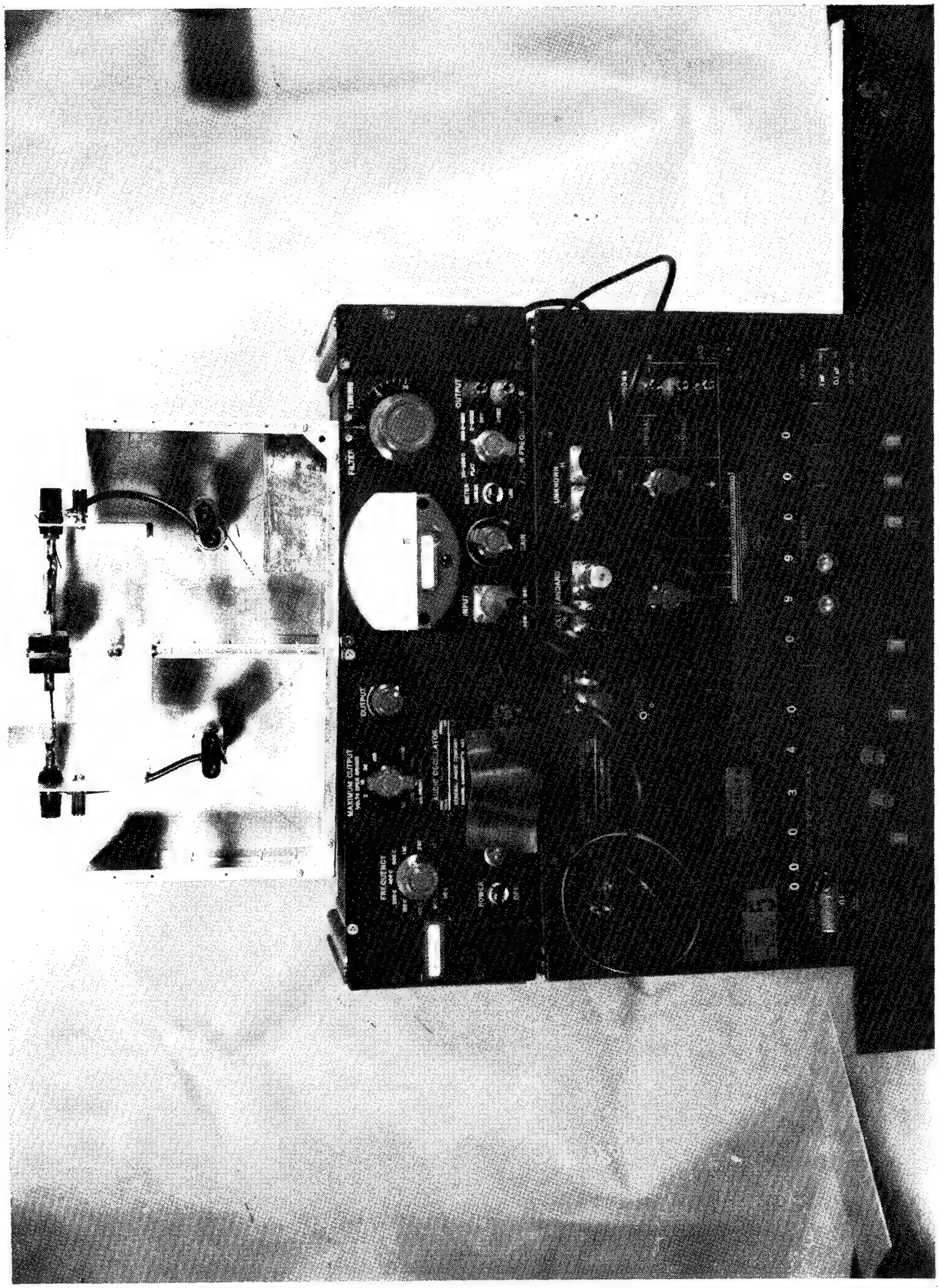


FIGURE 8-2 CAPACITY AND DISSIPATION FACTOR SETUP

TABLE 8-1

COLOR CHANGE

Material And Specimen Number	Apparent Color Change
1C2-5 1-R6-9	Change not apparent in black material
2-C2-5	Chalky grey changed to chalky, greenish-brown
2-R6-9	Chalky grey changed to dark brown
3-C2-5 3-R6-9	Change not apparent in black material
4-C2-5	Light yellow to dark yellow
4-R6-9	Light yellow to dark brown
5-C2-5	Milky brown (yellowish) to dark brown
5-R6-9	Milky brown (yellowish) to black
6-C2-5	Green (yellowish) to brown (greenish)
6-R6-9	Green (yellowish) to dark brown

TABLE 8-2

WEIGHT CHANGE,

ORGANIC CUBES, VIII-1

Specimen	WEIGHT CHANGE AFTER TEST					
	1st Weight 5-28-64		2nd Weight 6-30-64		3rd Weight 7-6-64	
	Grams	Percent	Grams	Percent	Grams	Percent
C2	-0.0487	-0.10	0.0529	-0.11	-0.0518	-0.11
C3	-0.0535	-0.11	--	--	-0.0549	-0.12
C4	-0.0426	-0.09	--	--	-0.0445	-0.10
C5	-0.0556	-0.12	-0.0576	-0.12	-0.0575	-0.12
Average	---	-0.11	---	-0.12	---	-0.11
R6	-0.1871	-0.40	-0.1975	-0.43	-0.1979	-0.43
R7	-0.1826	-0.39	---	--	-0.1935	-0.42
R8	-0.1722	-0.37	-0.1821	-0.39	-0.1828	-0.39
R9	-0.1845	-0.39	-0.1944	-0.42	-0.1947	-0.42
Average	---	-0.39	---	-0.41	---	-0.42

TABLE 8-3

WEIGHT CHANGE

ORGANIC CUBES, VIII-2

Specimen	WEIGHT CHANGE AFTER TEST					
	1st Weight 5-28-64		2nd Weight 6-30-64		3rd Weight 7-6-64	
	Grams	Percent	Grams	Percent	Grams	Percent
C2	-0.0441	-0.10	-0.0451	-0.10	-0.0452	-0.10
C3	-0.0531	-0.10	---	--	-0.0446	-0.09
C4	-0.0482	-0.09	-0.0494	-0.10	-0.0495	-0.10
C5	-0.0428	-0.09	---	--	-0.0615	-0.12
Average	---	-0.10	---	-0.10	---	-0.10
R6	-0.1515	-0.31	-0.1704	-0.35	-0.1713	-0.35
R7	-0.1753	-0.36	-0.2215	-0.46	-0.2216	-0.46
R8	-0.1774	-0.36	-0.1919	-0.39	-0.1923	-0.39
R9	-0.1661	-0.34	---	--	-0.1906	-0.39
Average	---	-0.34	---	-0.40	---	-0.40

TABLE 8-4

WEIGHT CHANGE

ORGANIC CUBES, VIII-3

Specimen	WEIGHT CHANGE AFTER TEST					
	1st Weight 5-28-64		2nd Weight 6-30-64		3rd Weight 7-6-64	
	Grams	Percent	Grams	Percent	Grams	Percent
C2	-0.0004	-0.001	+ 0.0763	+ 0.18	+ 0.0803	+ 0.19
C3	-0.0023	-0.005	—	—	+ 0.0712	+ 0.17
C4	-0.0056	-0.013	+ 0.0756	+ 0.18	+ 0.0747	+ 0.17
C5	-0.0040	-0.009	—	—	+ 0.0809	+ 0.19
Average	—	-0.007	—	+ 0.18	—	+ 0.18
R6	-0.1147	-0.26	-0.3060	-0.72	-0.3113	-0.73
R7	-0.1021	-0.24	-0.3150	-0.74	-0.3209	-0.75
R8	-0.0670	-0.16	--	--	-0.2575	-0.61
R9	-0.0573	-0.13	-0.2402	-0.56	-0.2445	-0.57
Average	—	-0.20	—	-0.67	—	-0.67

TABLE 8-5

WEIGHT CHANGE

ORGANIC CUBES, VIII-4

Specimen	WEIGHT CHANGE AFTER TEST					
	1st Weight 5-28-64		2nd Weight 6-30-64		3rd Weight 7-6-64	
	Grams	Percent	Grams	Percent	Grams	Percent
C2	-0.0535	-0.11	-0.0573	-0.12	-0.0586	-0.12
C3	-0.0389	-0.08	—	—	-0.0525	-0.11
C4	-0.0454	-0.09	-0.0454	-0.09	-0.0474	-0.10
C5	-0.0445	-0.09	-0.0445	-0.09	-0.0461	-0.09
Average	—	-0.09	—	-0.10	—	-0.11
R6	-0.1372	-0.27	-0.1457	-0.29	-0.1459	-0.29
R7	-0.1523	-0.31	—	—	-0.2175	-0.44
R8	-0.1654	-0.33	-0.1733	-0.35	-0.1730	-0.35
R9	-0.1698	-0.34	-0.1798	-0.36	-0.1799	-0.36
Average	—	-0.31	—	-0.33	—	-0.36

TABLE 8-6

WEIGHT CHANGE

ORGANIC CUBES, VIII-5

Specimen	WEIGHT CHANGE AFTER TEST					
	1st Weight 5-28-64		2nd Weight 6-30-64		3rd Weight 7-6-64	
	Grams	Percent	Grams	Percent	Grams	Percent
C2	-0.0371	-0.08	-0.0382	-0.08	-0.0379	-0.08
C3	-0.0353	-0.08	-0.0372	-0.08	-0.0373	-0.08
C4	-0.0335	-0.07	-0.0350	-0.07	-0.0345	-0.07
C5	-0.0354	-0.08	—	—	-0.0367	-0.08
Average	—	-0.08	—	-0.08	—	-0.08
R6	-0.1214	-0.26	—	—	-0.1291	-0.28
R7	-0.1307	-0.28	—	—	-0.1384	-0.30
R8	-0.1054	-0.23	-0.1159	-0.25	-0.1159	-0.25
R9	-0.1076	-0.23	-0.1162	-0.25	-0.1161	-0.25
Average	—	-0.25	—	-0.25	—	-0.27

TABLE 8-7

WEIGHT CHANGE

ORGANIC CUBES, VIII-6

Specimen	WEIGHT CHANGE AFTER TEST					
	1st Weight 5-28-64		2nd Weight 6-30-64		3rd Weight 7-6-64	
	Grams	Percent	Grams	Percent	Grams	Percent
C2	-0.0151	-0.03	—	—	-0.0238	-0.05
C3	-0.0171	-0.03	-0.0208	-0.04	-0.0209	-0.04
C4	-0.0152	-0.03	-0.0188	-0.04	-0.0185	-0.04
C5	-0.0127	-0.02	-0.0239	-0.05	-0.0240	-0.05
Average	—	-0.02	—	-0.04	—	-0.04
R6	-0.0804	-0.16	—	—	-0.0892	-0.17
R7	-0.0766	-0.15	-0.0840	-0.16	-0.0842	-0.16
R8	-0.0927	-0.18	-0.1005	-0.20	-0.1005	-0.20
R9	-0.0929	-0.18	—	—	-0.0999	-0.19
Average	—	-0.17	—	-0.18	—	-0.18

TABLE 8-8

ELECTRICAL PARAMETERS

(GROUP VIII-1, ORGANIC CUBES)

Specimen Identification	Insulation Resistance (Ω)		Capacitance (pF)		Dissipation Factor (%)	
	Pre-Test	Post-Test	Pre-Test	Post-Test	Pre-Test	Post-Test
VIII-1-A1	4.5×10^{15}	2.9×10^{15}	0.96701	0.95866	0.00400	0.00400
-C2	5.5×10^{15}	2.0×10^{15}	0.65810	0.63412	0.00392	0.00518
-C3	7.1×10^{15}	5.0×10^{15}	0.95165	0.89733	0.00359	0.00611
-C4	1.0×10^{16}	5.0×10^{15}	0.94847	0.90904	0.00386	0.00611
-C5	1.7×10^{16}	2.3×10^{15}	1.01809	0.95782	0.00384	0.00600
-R6	1.0×10^{16}	2.5×10^{15}	0.94709	0.89480	0.00360	0.00716
-R7	5.5×10^{15}	2.5×10^{15}	0.84035	0.80480	0.00424	0.00662
-R8	1.0×10^{15}	2.5×10^{15}	0.94131	0.90234	0.00401	0.00705
-R9	1.0×10^{15}	2.5×10^{15}	0.94750	0.90930	0.00399	0.00716

TABLE 8-9

ELECTRICAL PARAMETERS

(GROUP VIII-2, ORGANIC CUBES)

Specimen Identification	Insulation Resistance (Ω)		Capacitance (pF)		Dissipation Factor (%)	
	Pre-Test	Post-Test	Pre-Test	Post-Test	Pre-Test	Post-Test
VIII-2-A1	1.2×10^{16}	1.7×10^{16}	1.11226	1.10471	0.00234	0.00224
-C2	1.7×10^{16}	4.5×10^{15}	1.08469	1.04006	0.00267	0.00433
-C3	1.2×10^{16}	1.7×10^{16}	1.09938	1.05425	0.00240	0.00396
-C4	8.3×10^{15}	2.3×10^{15}	1.07493	1.04001	0.00248	0.00400
-C5	4.5×10^{15}	5.0×10^{15}	1.07958	1.00466	0.00235	0.00417
-R6	8.3×10^{15}	3.6×10^{15}	1.10778	1.06302	0.00241	0.00566
-R7	7.1×10^{15}	1.6×10^{15}	1.06166	1.04238	0.00262	0.00556
-R8	2.5×10^{16}	2.1×10^{15}	1.05119	0.99633	0.00262	0.00540
-R9	1.2×10^{16}	3.1×10^{15}	1.06546	1.06613	0.00272	0.00566

TABLE 8-10

ELECTRICAL PARAMETERS

(GROUP VIII-3, ORGANIC CUBES)

Specimen Identification	Insulation Resistance (Ω)		Capacitance (pF)		Dissipation Factor (%)	
	Pre-Test	Post-Test	Pre-Test	Post-Test	Pre-Test	Post-Test
VIII-3-A1	2.3×10^{15}	1.5×10^{15}	0.81750	0.74461	0.0007	0.0008
-C2	2.5×10^{16}	5.0×10^{15}	0.58871	0.69726	0.0006	0.00110
-C3	2.5×10^{16}	3.3×10^{15}	0.46100	0.76699	0.0006	0.00111
-C4	5.0×10^{16}	2.5×10^{15}	0.44326	0.79189	0.0005	0.00112
-C5	5.5×10^{15}	1.6×10^{15}	0.75900	0.77226	0.0007	0.00111
-R6	8.3×10^{15}	5.0×10^{15}	0.52259	0.53728	0.0006	0.00100
-R7	6.2×10^{15}	5.0×10^{15}	0.43649	0.61263	0.0006	0.00100
-R8	3.6×10^{15}	5.0×10^{15}	0.45591	0.76023	0.0005	0.00120
-R9	1.6×10^{15}	2.5×10^{15}	0.54445	0.72145	0.0006	0.00111

TABLE 8-11

ELECTRICAL PARAMETERS

(GROUP VIII-4, ORGANIC CUBES)

Specimen Identification	Insulation Resistance (Ω)		Capacitance (pF)		Dissipation Factor (%)	
	Pre-Test	Post-Test	Pre-Test	Post-Test	Pre-Test	Post-Test
VIII-4-A1	4.5×10^{15}	5.0×10^{15}	1.20606	1.18620	0.00316	0.00316
-C2	2.2×10^{15}	3.8×10^{15}	1.23727	1.19665	0.00309	0.00431
-C3	8.3×10^{15}	5.0×10^{15}	1.15850	1.13709	0.00326	0.00439
-C4	2.8×10^{15}	8.3×10^{15}	1.19052	1.16343	0.00301	0.00427
-C5	8.3×10^{15}	3.6×10^{15}	1.18806	1.15773	0.00305	0.00425
-R6	5.5×10^{15}	5.0×10^{15}	1.19140	1.17651	0.00330	0.00530
-R7	2.3×10^{15}	5.0×10^{15}	1.22710	1.18835	0.00300	0.00515
-R8	7.1×10^{15}	5.0×10^{15}	1.23007	1.19721	0.00290	0.00519
-R9	3.3×10^{15}	3.8×10^{15}	1.22947	1.20774	0.00298	0.00521

TABLE 8-12

ELECTRICAL PARAMETERS

(GROUP VIII-5, ORGANIC CUBES)

Specimen Identification	Insulation Resistance (Ω)		Capacitance (pF)		Dissipation Factor (%)	
	Pre-Test	Post-Test	Pre-Test	Post-Test	Pre-Test	Post-Test
VIII-5-A1	1.0×10^{16}	4.5×10^{15}	0.94760	0.94558	0.00210	0.00209
-C2	6.2×10^{15}	4.5×10^{15}	0.92230	0.91261	0.00290	0.00412
-C3	1.0×10^{16}	1.0×10^{16}	0.94680	0.94520	0.00260	0.00395
-C4	1.6×10^{16}	2.9×10^{15}	0.93830	0.92197	0.00241	0.00406
-C5	6.2×10^{15}	6.2×10^{15}	0.92660	0.91762	0.00240	0.00416
-R6	1.0×10^{16}	5.0×10^{15}	0.94640	0.95135	0.0021 0	0.00501
-R7	1.0×10^{16}	5.0×10^{15}	0.91536	0.95039	0.00210	0.00493
-R8	5.6×10^{16}	4.2×10^{15}	0.95160	0.96817	0.00270	0.00539
-R9	1.0×10^{16}	7.1×10^{15}	0.95520	0.94844	0.00230	0.00534

TABLE 8-13

ELECTRICAL PARAMETERS

(GROUP VIII-6, ORGANIC CUBES)

Specimen Identification	Insulation Resistance (Ω)		Capacitance (pF)		Dissipation Factor (%)	
	Pre-Test	Post-Test	Pre-Test	Post-Test	Pre-Test	Post-Test
VIII-6-A1	1.2×10^{14}	4.2×10^{13}	1.20520	1.19424	0.02840	0.0273
-C2	8.3×10^{13}	3.1×10^{13}	1.17100	1.14087	0.02720	0.0258
-C3	1.4×10^{14}	2.9×10^{13}	1.17560	1.13795	0.02800	0.0262
-C4	2.0×10^{14}	3.6×10^{13}	1.17040	1.13997	0.02720	0.0260
-C5	1.2×10^{14}	4.2×10^{13}	1.18570	1.14929	0.02740	0.0261
-R6	1.0×10^{14}	3.8×10^{13}	1.21560	1.17910	0.02720	0.0251
-R7	1.2×10^{14}	3.8×10^{13}	1.19550	1.16065	0.02700	0.0254
-R8	1.2×10^{14}	3.3×10^{13}	1.15390	1.11568	0.02740	0.0253
-R9	4.5×10^{14}	3.8×10^{13}	1.20140	1.16577	0.02710	0.0252

9.0 TEST SPECIMENS

GROUP IX INORGANIC CUBES

IX-1 Inorganic potting compound, Calcium Aluminate Type, Norton Company, Product No. LM 1625.

IX-2 Inorganic potting compound, Calcium Aluminate Type, Norton Company, Product No. HD 33.

9.1 PROCEDURE

The procedures as outlined in the Experimental Design Manual ND-5001, Revised 27 April 1964, were followed. The test configurations are shown in Figures 8-1 and 8-2.

9.2 NUCLEAR ENVIRONMENT

	NEUTRON FLUX		GAMMA DOSE	
Material	Rate $n/cm^2/sec$	Integrated n/cm	Rate Rads/hr.	Integrated Rads
1	7.7×10^7	3.7×10^{13}	7.3×10^5	9.9×10^7
2	8.4×10^7	4.1×10^{13}	7.3×10^5	1.0×10^8

9.3 RESULTS

9.3.1 Insulation Resistance

The results of the insulation resistance measurements for the inorganic cubes are shown in Tables 9-1 and 9-2. The results of the pre- and post-measurements show no significant changes to conclude the presence of temperature or radiation effects.

9.3.2 Dielectric Constant

The calculation of dielectric constants were not determined since the geometry prohibited calculations to any reasonable accuracy. Comparison of capacitance measurements are shown in Tables 9-1 and 9-2. The changes in capacitance values appear to be of little significance.

9.3.3 Dissipation Factor

The results of the dissipation factor measurements are shown in Tables 9-1 and 9-2. The changes, though large in some cases, were probably due to the moisture content. However, the (-2) irradiated specimens did show a consistent increase in dissipation factor.

9.3.4 Dielectric Strength

The results of the dielectric breakdown test are shown in Tables 9-1 and 9-2. No significant differences in these values are apparent.

9.3.5 Visual

No color changes were evident in the control or irradiated specimens.

TABLE 9-1

ELECTRICAL PARAMETERS

(GROUP IX-1, INORGANIC CUBES)

Specimen Identification	Insulation Resistance (Ω)		Capacitance (pF)		Dissipation Factor (%)		Dielectric Breakdown Voltage VAC-RMS
	Pre-Test	Post-Test	Pre-Test	Post-Test	Pre-Test	Post-Test	
IX-1-A1	1.4×10^{14}	4.8×10^{13}	1.48420	1.46996	0.0069	0.0150	5,600
-C2	1.7×10^{16}	2.1×10^{12}	1.40640	1.34731	0.0183	< 0.00001	5,700
-C3	3.3×10^{15}	2.8×10^{13}	1.35462	1.29122	0.0199	< 0.00001	4,800
-C4	2.9×10^{15}	4.5×10^{13}	1.31990	1.27141	0.0142	< 0.00001	5,300
-C5	3.3×10^{15}	3.6×10^{12}	1.29650	1.21270	0.0158	< 0.00001	4,900
-R6	1.2×10^{15}	2.3×10^{12}	1.44230	1.43680	0.0085	0.0046	4,600
-R7	3.1×10^{14}	1.6×10^{14}	1.35430	1.35895	0.0103	0.0160	3,400
-R8	4.2×10^{14}	2.5×10^{14}	1.46750	1.44210	0.0176	0.0001	6,800
-R9	1.0×10^{15}	8.1×10^{13}	1.47420	1.47923	0.0086	0.0155	5,600

TABLE 9-2

ELECTRICAL PARAMETERS

(GROUP IX-2, INORGANIC CUBES)

Specimen Identification	Insulation Resistance (Ω)		Capacitance (pF)		Dissipation Factor (%)		Dielectric Breakdown Voltage VAC-RMS
	Pre-Test	Post-Test	Pre-Test	Post-Test	Pre-Test	Post-Test	
IX-2-A1	2.9×10^{13}	9.6×10^{12}	1.74732	1.76010	0.0464	0.0595	5,100
-C2	6.2×10^{13}	7.0×10^{12}	2.11830	2.07552	0.0326	0.0330	3,800
-C3	8.3×10^{13}	8.6×10^{12}	1.88840	1.76646	0.0313	0.0182	4,800
-C4	1.0×10^{14}	1.8×10^{12}	1.76620	1.68800	0.0210	0.0166	4,600
-C5	5.1×10^{12}	8.1×10^{12}	1.94750	1.90010	0.0267	0.0229	4,300
-R6	7.1×10^{13}	3.4×10^{12}	2.04590	2.00445	0.0290	0.0830	4,700
-R7	1.4×10^{13}	2.0×10^{12}	2.02650	2.05705	0.0396	0.1046	4,400
-R8	6.2×10^{13}	2.6×10^{12}	2.01310	2.02215	0.0315	0.0940	4,200
-R9	2.9×10^{13}	4.8×10^{12}	2.01700	2.02533	0.0325	0.0885	4,000

10.0 TEST SPECIMEN

GROUP X CERAMIC THRU-TYPE TERMINALS

X-1 Advac, Product No. A-608, Type 1, Stamford, Conn.

X-2 Advac, Product No. 500-C, Type 2, Stamford, Conn.

X-3 Advac, Product No. 250ES, Type 3, Stamford, Conn.

X-4 Alite Tubular, P/N B-50-13

X-6 McCullough, Type CA 8005

10.1 PROCEDURE

The procedures as outlined in the "Experimental Design Manual" ND-5001, Revised 27 April 1964, were performed.

10.2 NUCLEAR ENVIRONMENT

	NEUTRON FLUX		GAMMA DOSE	
	Rate	Integrated	Rate	Integrated
Material	$n/cm^2/sec$	n/cm	Rads/hr.	Rads
1	8.5×10^7	4.2×10^{13}	6.8×10^5	9.3×10^7
2	8.5×10^7	4.2×10^{13}	6.8×10^5	9.3×10^7
3	8.5×10^7	4.2×10^{13}	6.8×10^5	9.3×10^7
4	8.5×10^7	4.2×10^{13}	6.8×10^5	9.3×10^7

10.3 RESULTS

10.3.1 Visual

All the irradiated specimens showed some color changes with the ceramic portion of the terminal being darker. Since no terminals were subjected to the control test, this change could be attributed to either irradiation or temperature.

10.3.2 Helium Leak Check

Post irradiation tests revealed the presence of no leaks.

10.3.3 Insulation Resistance

The results of the insulation resistance measurements are shown in Table 10-1. There appears to be no significant changes in the terminals.

TABLE 10-1

INSULATION RESISTANCE CERAMIC - THRU-TYPE TERMINALS

SPECIMEN IDENTIFI-CATION	INSULATION RESISTANCE					
	PRE-TEST			POST-TEST		
	@ 500 VDC	@ 1000 VDC	@ 1500 VDC	@ 500 VDC	@ 1000 VDC	@ 1500 VDC
X-1-A1	5.0×10^{14}	6.1×10^{14}	7.1×10^{14}	1.9×10^{14}	2.4×10^{14}	2.3×10^{14}
X-1-R1	4.9×10^{14}	6.7×10^{14}	7.5×10^{14}	3.0×10^{14}	6.7×10^{14}	7.1×10^{14}
X-1-R2	6.0×10^{14}	8.3×10^{14}	9.4×10^{14}	3.3×10^{14}	5.9×10^{14}	7.7×10^{14}
X-2-A1	4.2×10^{13}	6.7×10^{13}	7.9×10^{13}			
X-2-R1	6.9×10^{13}	8.3×10^{13}	1.0×10^{14}	3.0×10^{14}	5.1×10^{14}	6.1×10^{14}
X-2-R2	7.4×10^{13}	1.1×10^{14}	1.2×10^{14}	4.0×10^{14}	6.2×10^{14}	8.6×10^{14}
X-3-A1	3.1×10^{14}	4.2×10^{14}	5.0×10^{14}	1.8×10^{14}	2.8×10^{14}	3.0×10^{14}
X-3-R1	1.5×10^{14}	1.7×10^{14}	1.7×10^{14}	2.3×10^{14}	4.9×10^{14}	7.1×10^{14}
X-3-R2	3.7×10^{14}	5.1×10^{14}	5.5×10^{14}	3.2×10^{14}	5.6×10^{14}	9.1×10^{14}
X-4-A1	2.6×10^{15}	3.1×10^{15}	3.6×10^{15}			
X-4-R1	1.9×10^{15}	2.9×10^{15}	3.7×10^{15}	2.3×10^{14}	4.8×10^{14}	7.3×10^{14}
X-4-R2	1.2×10^{15}	1.8×10^{15}	2.3×10^{15}	1.9×10^{14}	4.1×10^{14}	6.4×10^{14}

11.0 TEST SPECIMENS

GROUP XI - STATORETTES

XI-1 AGC Motor Statorette - Organic Insulation System - Nitrogen Cover Gas

XI-2 AGC Motor Statorette - Inorganic Insulation System - Capsule Evacuated

XI-3 GE Statorette - Organic Insulation System with ET-378 Fluid in Capsule

11.1 PROCEDURE

The procedure was as outlined in "Experimental Design Manual," ND 5001, Revision dated 27 April 1964 except as follows; Figures 11-13 through 11-16, show typical views of the process of statorette encapsulation.

11.1.1 Insulation Resistance

11.1.1.1 Irradiated Specimens

Pre-exposure measurements at ambient temperature and 392° F were not obtained due to instrumentation and scheduling difficulties. The grounded guard circuit used in making the measurements were changed during the test to permit leakage measurements between two points to be accurately made. Extraneous leakage currents were present in the previous arrangement. The following connections were used for the majority of the test:

Condition	
A	A ϕ to B ϕ with C ϕ and Iron shorted to ground.
B	B ϕ to C ϕ with A ϕ and Iron shorted to ground.

Condition

C	C ϕ to A ϕ with B ϕ and Iron shorted to ground.
D	A ϕ to Iron with B ϕ and C ϕ shorted to Iron.
D'	A ϕ to Iron with B ϕ and C ϕ shorted to ground.
E'	B ϕ to Iron with A ϕ and C ϕ shorted to ground.
F'	C ϕ to Iron with A ϕ and B ϕ shorted to ground.
I	A ϕ to B ϕ with C ϕ shorted to Iron.

Condition A and D were also measured using reverse polarity at 750 VDC only.

Insulation resistance readings were made as soon as the current stabilized - usually less than one (1) minute as called for in ND 5001.

Ten-minute readings were not made because little or no change in current was observed after the initial value was reached.

Helium leak tests on the capsules and statorette visual examinations was not performed. These tests were deferred until several added tests could be accomplished and will be reported later.

11.2 NUCLEAR ENVIRONMENT

Specimen Group	Neutrons $n/cm^2/sec$	Neutrons n/cm^2	Gammas Rads/Hr	Gammas Rads
XI-1R	8.3×10^7	4.0×10^{13}	7.9×10^5	1.09×10^8
XI-2R	8.5×10^7	4.1×10^{13}	7.8×10^5	1.06×10^8
XI-3R	9.3×10^7	4.6×10^{13}	7.8×10^5	1.06×10^8

NOTE: Data tables and plots in this section show integrated gamma doses. The proportionate neutron exposure as shown above also existed.

11.3 RESULTS

Statorette iron temperatures curves are shown on Figures 11-21 and 11-22.

11.3.1 AC Proof Test

All specimens were subjected to the AC proof test with satisfactory results. Figure 11-13 shows the test setup.

11.3.2 Insulation Resistance

The results of the insulation resistance measurements are shown in Table 11-1 thru 11-12. The curve from test start to the 27-hour point reflects a lower insulation resistance because the guard circuit during that interval did not include all unwanted leakage paths. The shape of the two curves are seen to be alike but with a magnitude difference between them.

There appears to be little or no change in the resistance values as a function of irradiation with the exception of XI-1. Figures 11-1 and 11-2 show insulation resistance plotted against elapsed time for two conditions, Figure 11-1, B ϕ to C ϕ and Figure 11-2, B ϕ to Iron. The control specimen values are included in these plots to show the variation in resistance as a function of elapsed time

relative to the irradiated specimen. A decrease in resistance on the order of one magnitude was exhibited by the irradiated specimen. It is evident that the control specimen insulation resistance was nominally one order of magnitude lower that the irradiated specimen. This variance could be attributed to differences in the two insulation systems or to the curing of the insulation in the two specimens.

A comparison of the during-irradiation curve and the zero power (reactor shutdown) points show the presence of a rate effect caused by ionization produced in the insulation material. The contribution from the surrounding gasses should be small since there was no exposed (bare) wires in the statorettes. Annealing effects are small as they are not evident from the plotted curves. The slope of the curves shortly after start up appear to be extensions of the "before shutdown" curve. This is normal where little or no annealing has occurred.

Table 11-2, -4, -6, -8, -10, and -12, show the effects of temperature on the control specimens. There is a definite decrease in insulation resistance from the values obtained at ambient temperature to those at 386° F. These decreasing changes range from three to four orders of magnitude on the XI-1, two orders on XI-2, and from two to four orders on XI-3, the change in insulation resistance values on XI-3 of the control specimen and the irradiated specimen initial values could be attributed to small variations in temperature. A four order of magnitude change in insulation resistance is present from ambient to 386° F. Thus a very small temperature differential could account for the observed difference. Figures 11-18 and 11-19 show test setups in the laboratory and reactor area respectively.

11.3.3 Capacitance and Dissipation Factor

The results of the capacitance and dissipation factor measurements are shown in Tables 11-13 thru 11-18 and Figures 11-3 thru 11-12. Capacitance and dissipation factors shown in the figures are normalized values based on each individual

statorettes initial values. The tables show the actual measured value of capacitance and dissipation factor. The difference in the measurements of the control and irradiated specimens were due to a partial guard circuit. The electrical connection was intended to permit measurement of the capacitance and dissipation factors with the unused elements open. The large cable capacitance to ground of the open elements resulted in a partial guard circuit for the irradiated specimens, causing the apparent three to one capacity difference. As shown in the tables, normalizing the data effectively eliminated the apparent anomaly.

The comments concerning rate effects and annealing made in paragraph 11.3.2 apply to the capacity and dissipation factor sections; however, rate effects on the XI-2 units are low or non-existent. A hump apparent in the curves at about 150 hours is considered to be a temperature effect attributable to gamma heating of the iron. The gamma heat contribution raised the temperature of the iron by approximately 15° F for XI-1 and XI-2 units and approximately 25° F for the XI-3 statorette.

11.3.3.1 Group XI-1

The results of the capacitance and dissipation factor measurements are shown in Tables 11-13, Figures 11-3 and 11-4. Figures 11-3 and 11-4 show normalized capacitance and dissipation factor plotted against elapsed time. No values are included for the control specimen due to difficulties encountered during the test. The A ϕ gave an open indication shortly after the start of the test. Post-exposure capacity tests indicated an open condition on A ϕ and B ϕ . Examination after cool down revealed broken lead wires on both A and B Phases. Chamber vibration transmitted to the leads probably produced the malfunction.

Repairs were effected and measurements made at ambient temperature. The results are tabulated in Table 11-18. The normalized values, shown on the ordinate of the plot are based on the capacitance and dissipation values taken at ambient

temperature. There is a definite increase in both capacitance and dissipation as a function of irradiation. Dissipation changed by a factor of approximately 250 whereas the capacitance changed by a factor of approximately 3.5.

11.3.3.2 Group XI-2

The results of the capacitance and dissipation factor measurements are shown in Table 11-14 and 11-15, and on Figures 11-5 thru 11-8. The figures show a normalized capacitance and dissipation factor plotted against elapsed time for two conditions; Aϕ to Bϕ and Aϕ to Iron. Ordinate values were normalized to the ambient temperature values. There appears to be a rate effect on both capacitance and dissipation factor with a marked increase in the measured values of each. Common to irradiation and control plots, there is a decrease in values from the beginning of the test period to the end. This decrease could partially be attributed to drying or conditioning. The control specimens exhibit this change of decreasing values but not to the extent the irradiated specimens show. The near homogeneous heating, resulting from the gamma irradiation, could account for the sharp initial decrease in both capacitance and dissipation factor. It appears that the irradiated specimen values are approaching an asymptote parallel to the control specimen and that the curves would become essentially parallel with the separation between them attributable to a rate effect.

11.3.3.3 Group XI-3

The results of the capacitance and dissipation measurements are shown in Tables 11-16 and 11-17 and on Figures 11-9 thru 11-12. The figures show capacitance and dissipation factor, normalized against ambient values, and plotted against elapsed time for two conditions; Aϕ to Bϕ and Aϕ to iron. Figures 11-10, and 11-12 reveal a change in capacitance from the pre-test value as a function of irradiation and elapsed time. There appears to be a rate effect on capacitance but within approximately 25 hours the value had decreased to below the 390° F pre-test value.

The capacitance of the control specimens also shows a decrease as a function of elapsed time. Dissipation, in contrast to capacitance, increased as a function of irradiation. The change in dissipation of the control specimen as a function of elapsed time appears to be of no significance. In general, the capacitance decreases with both irradiation and temperature, while the dissipation increases with irradiation and remains fairly constant with temperature.

In the case of Figures 11-9 and 11-11, the initial offset in the normalized values of dissipation factor of the control specimen and irradiated specimen could be attributed to variations in temperature. The internal statorette temperature lagged the oven temperature by approximately 12 hours.

11.3.4 Dielectric Strength

The results of the dielectric breakdown voltage tests are shown in Table 11-19. With the exception of XI-2 there appears to be no significant change in the breakdown voltage. The voltage required to breakdown the XI-2R statorette is approximately one third that required for the control specimen. This change is attributed to either the presence of ionizing radiation at the time of breakdown, or a difference in the gas pressure in the two capsules. It is unlikely that any permanent change would have resulted from the irradiation since inorganic damage thresholds are reported by many investigators to be several orders of magnitude higher than that received in this test.

Since inorganic type insulation systems and in particular the XI-2 system have a porous type structure. Free ion mobility is a characteristic of this system. Even though the preconditioning was designed to remove air and moisture, there still exists a substantial number of gas molecules. In the presence of a radiation field the gas would ionize. This effect would aid conduction in the dielectric causing

a decrease in the breakdown voltage.

Figure 11-20 shows the distribution type transformers used in this test.

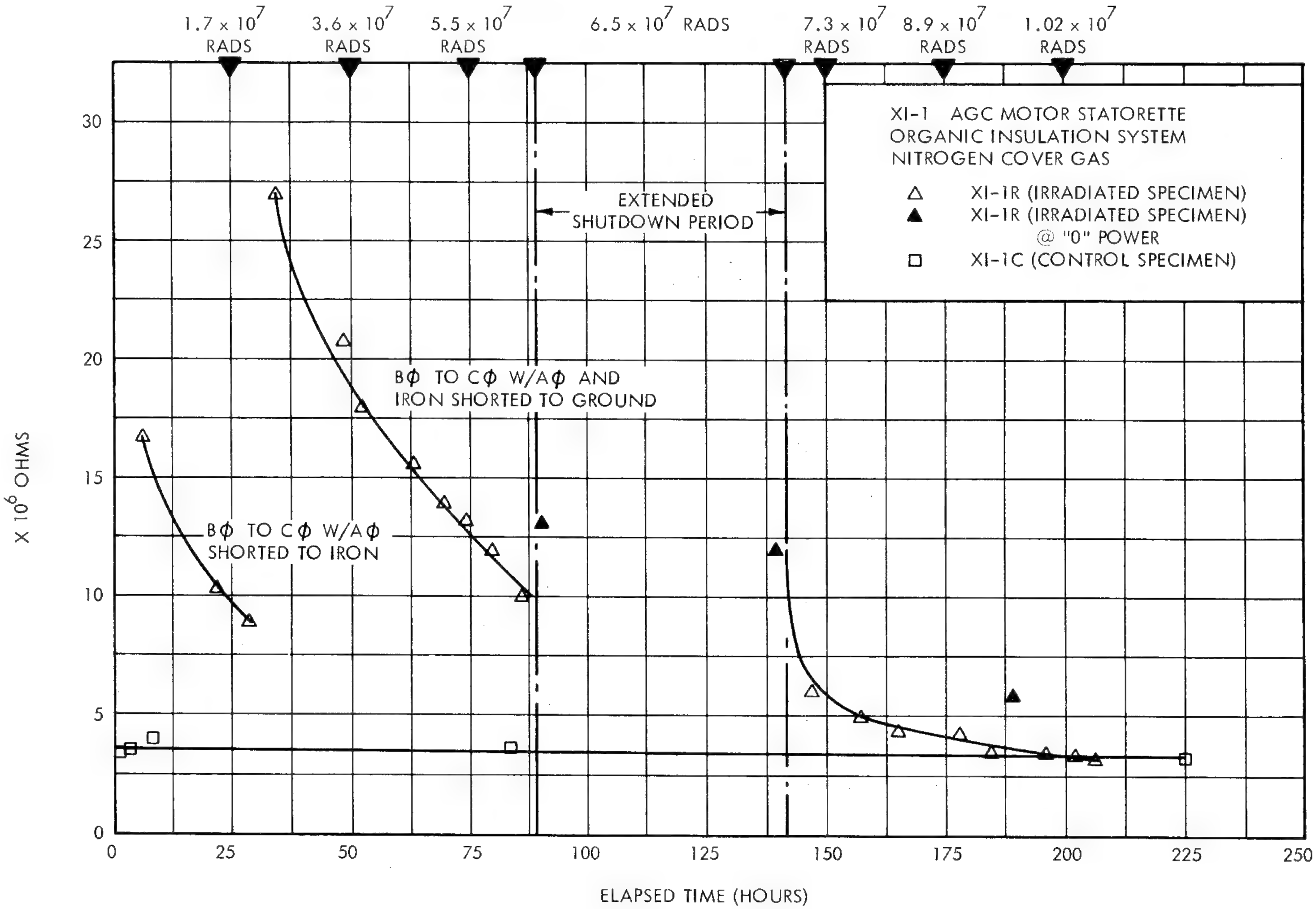


FIGURE 11-1 INSULATION RESISTANCE XI-1 STATORETTE Bϕ — Cϕ

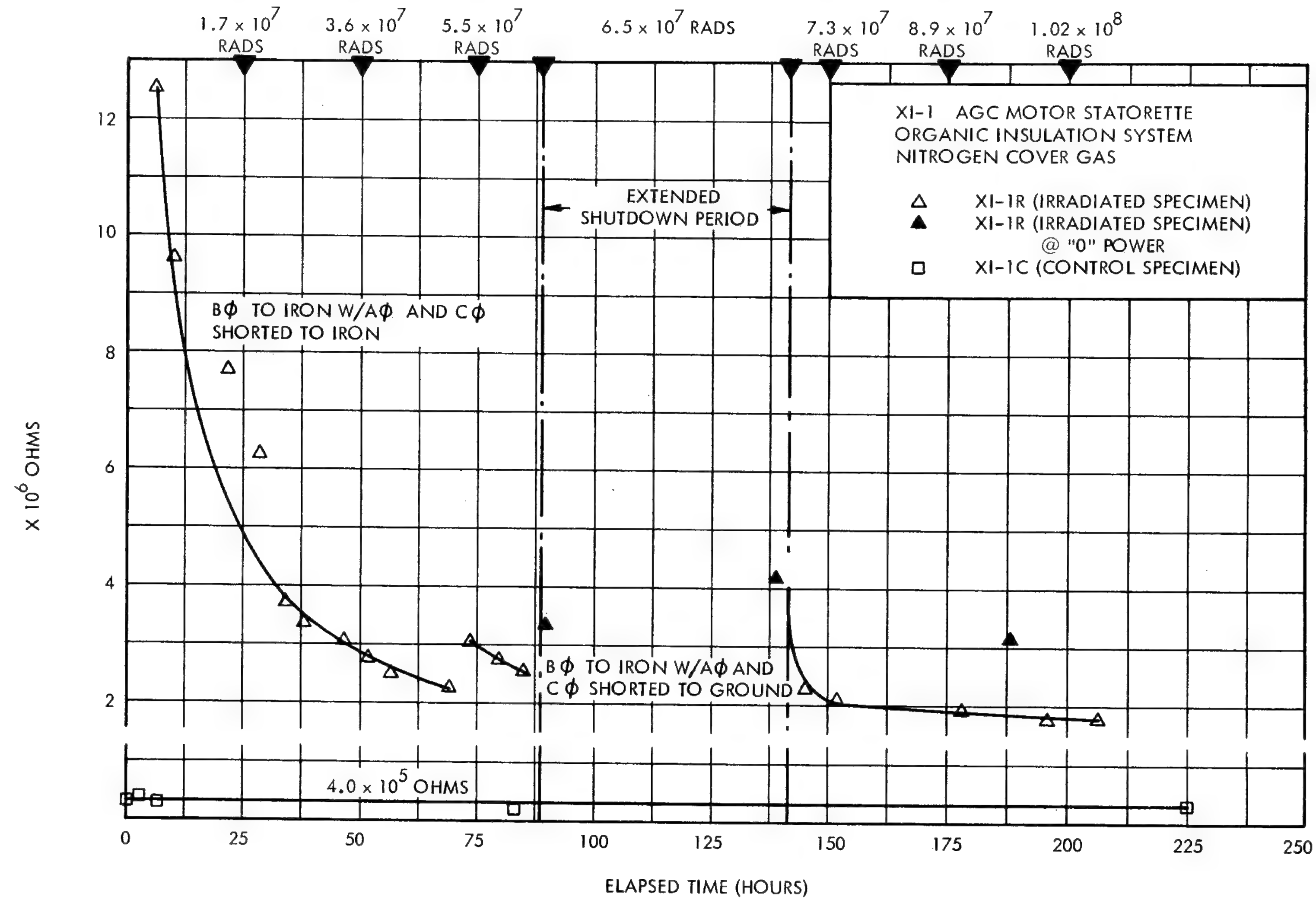


FIGURE 11-2 INSULATION RESISTANCE XI-1 STATORETTE B ϕ — IRON

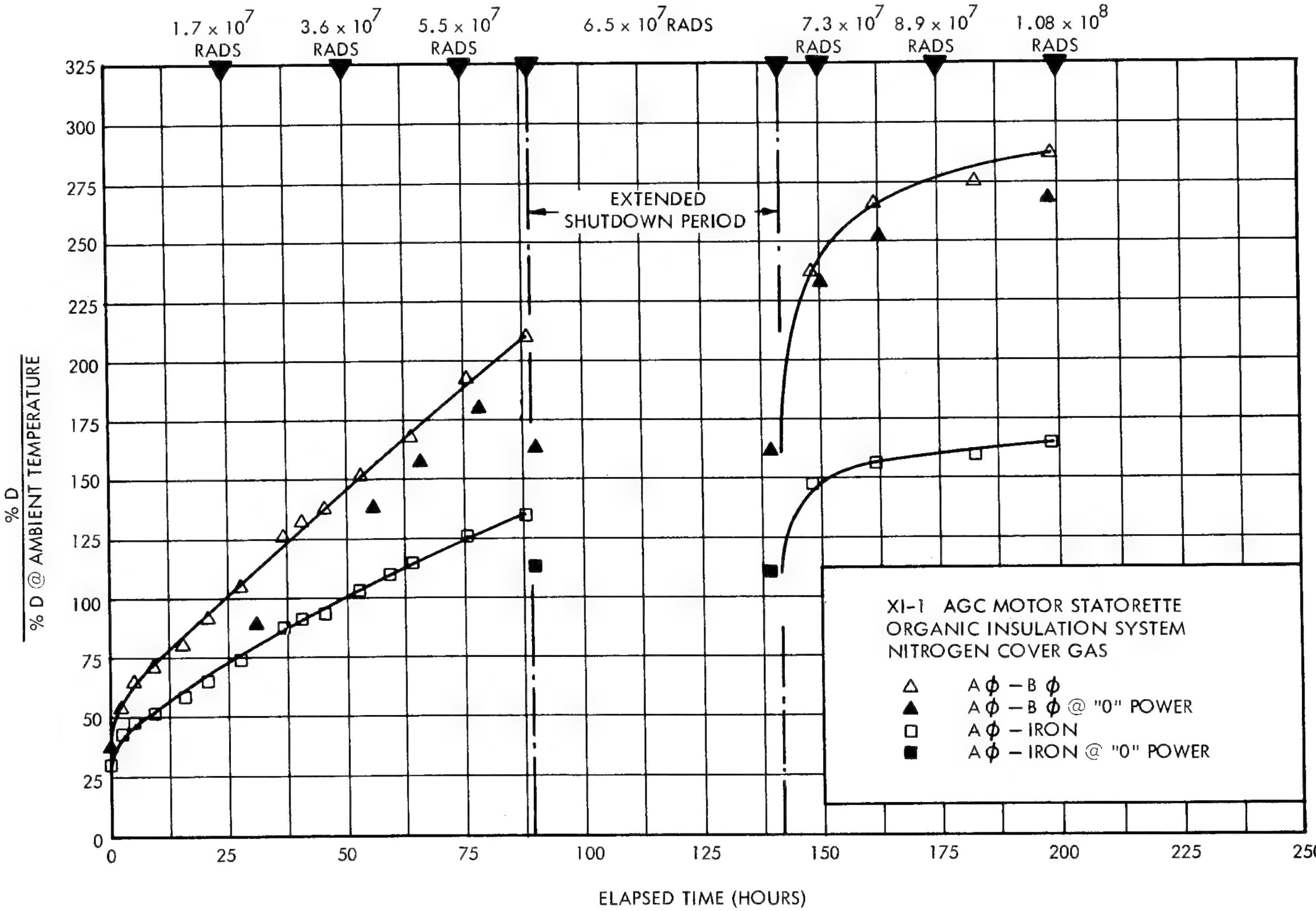


FIGURE 11-3 DISSIPATION FACTOR XI-1 STATORETTE

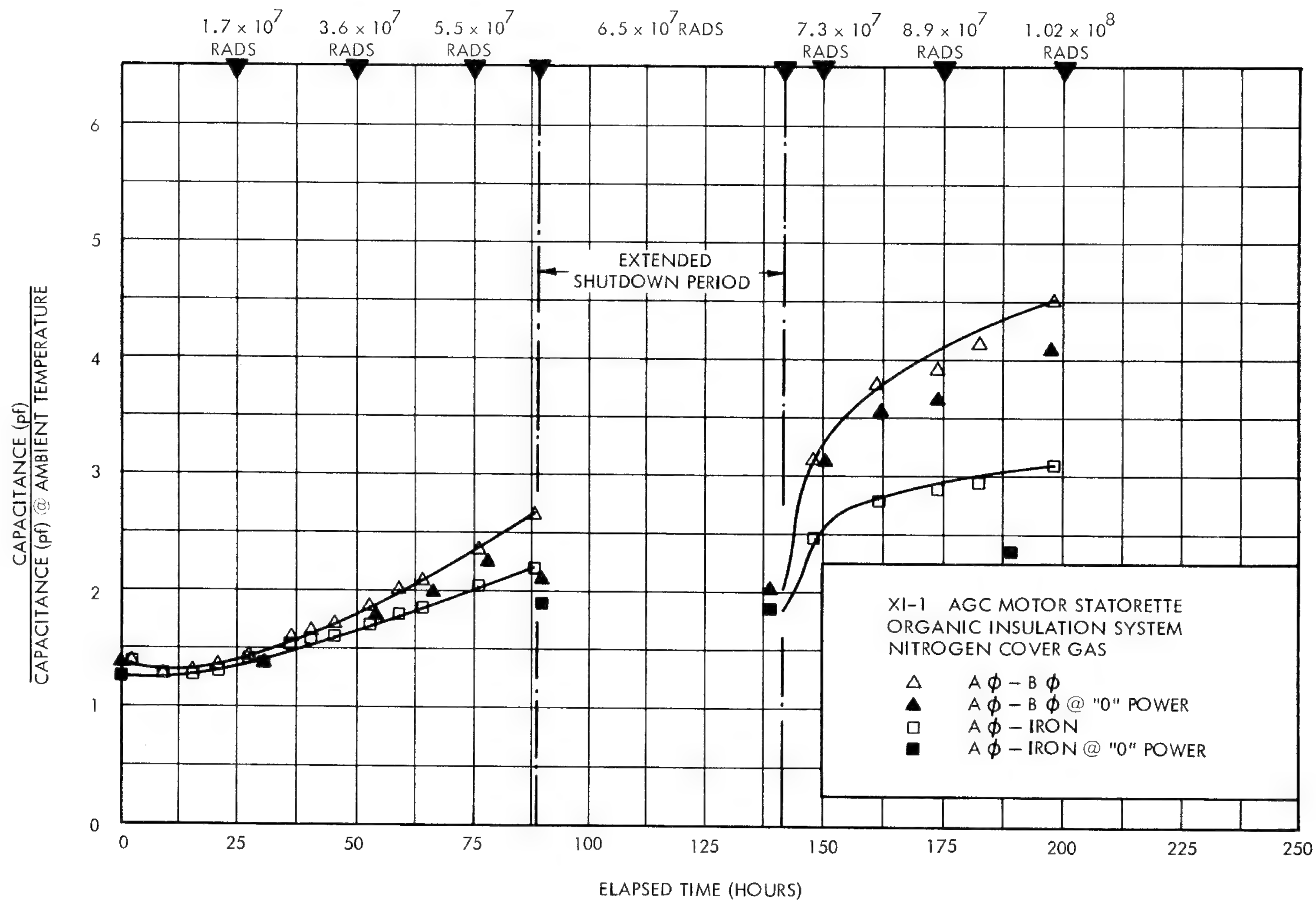


FIGURE 11-4 CAPACITANCE XI-1R STATORETTE

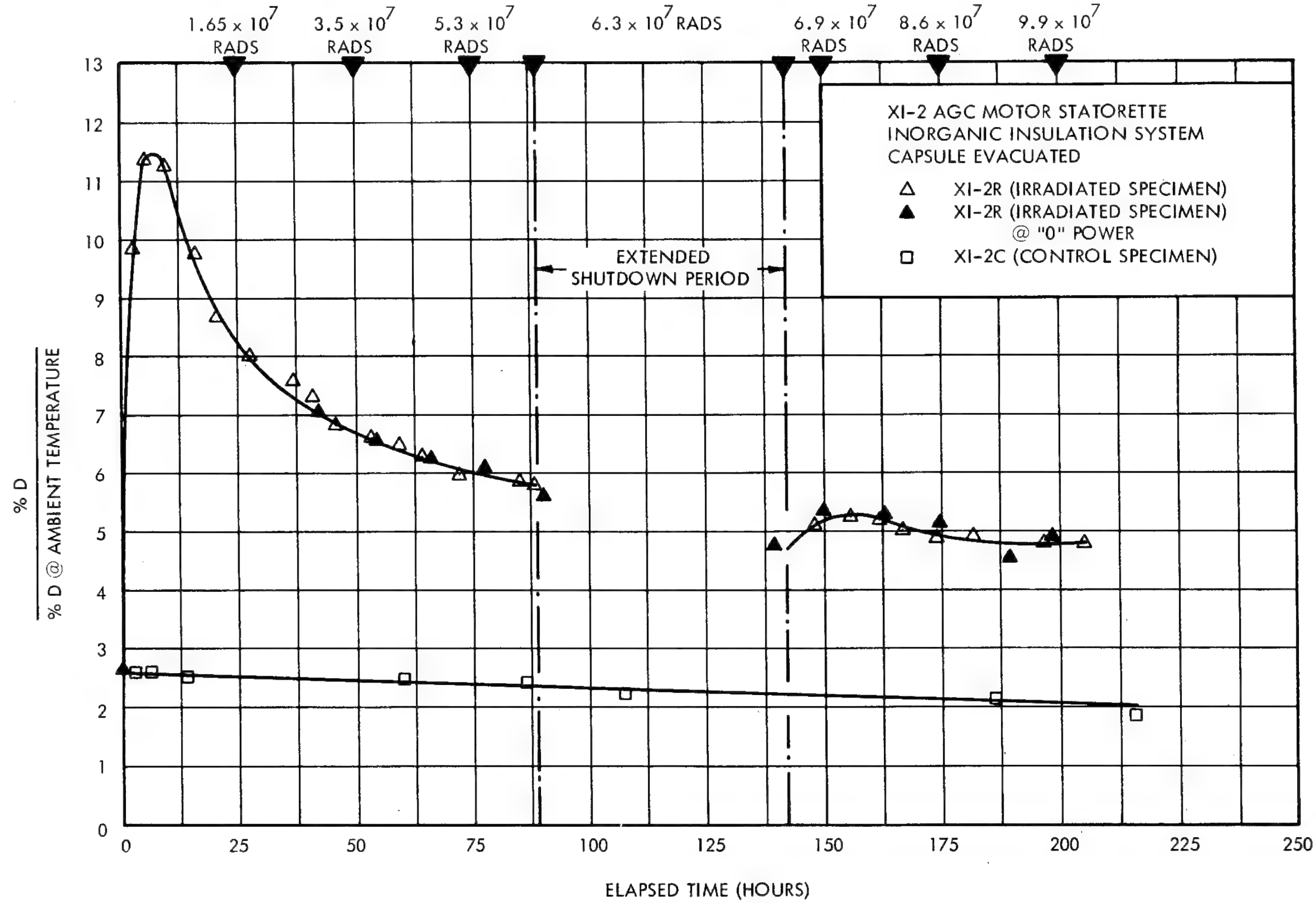


FIGURE 11-5 DISSIPATION FACTOR A ϕ – B ϕ XI-2 STATORETTE

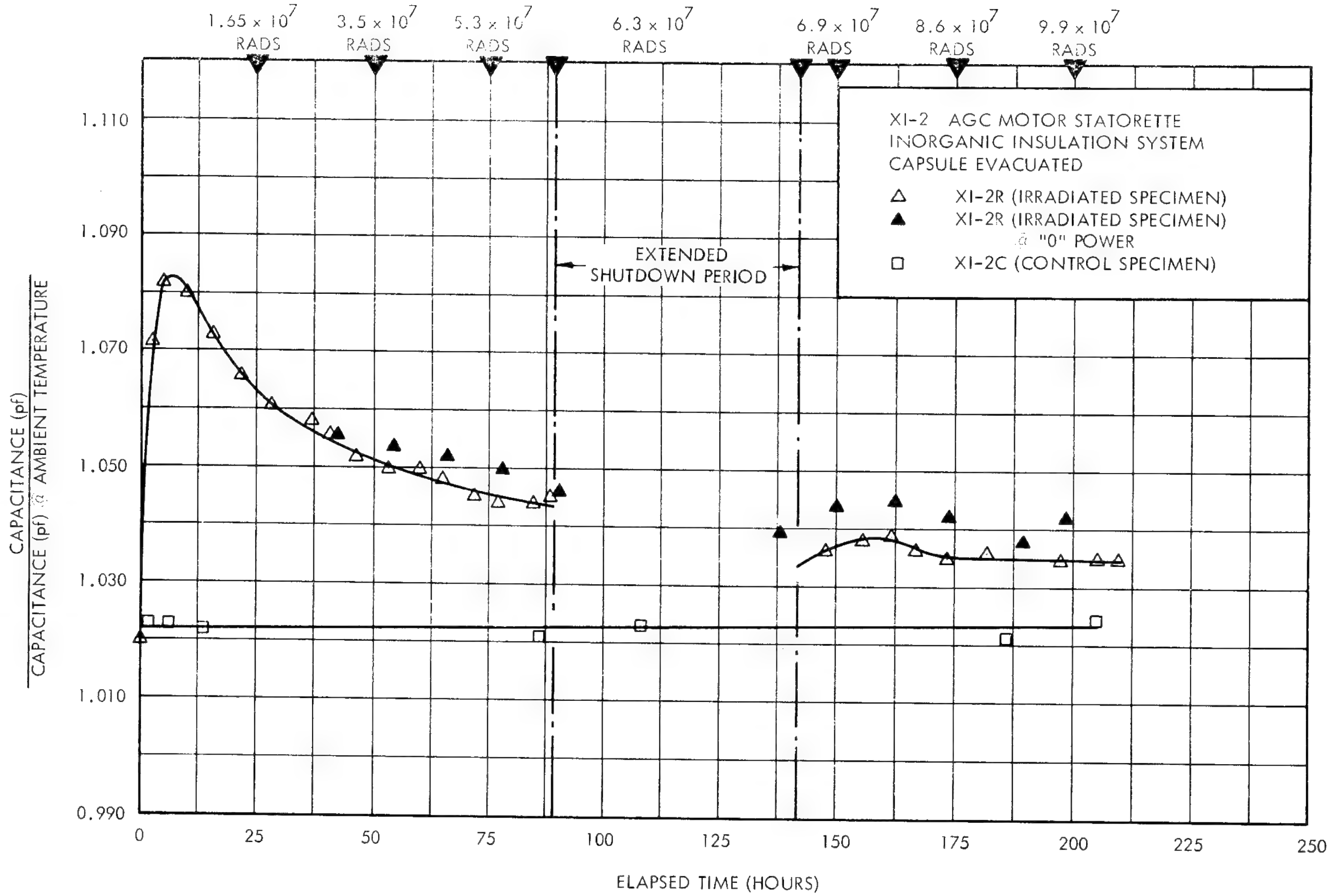


FIGURE 11-6 CAPACITANCE Aϕ – Bϕ XI-2 STATORETTE

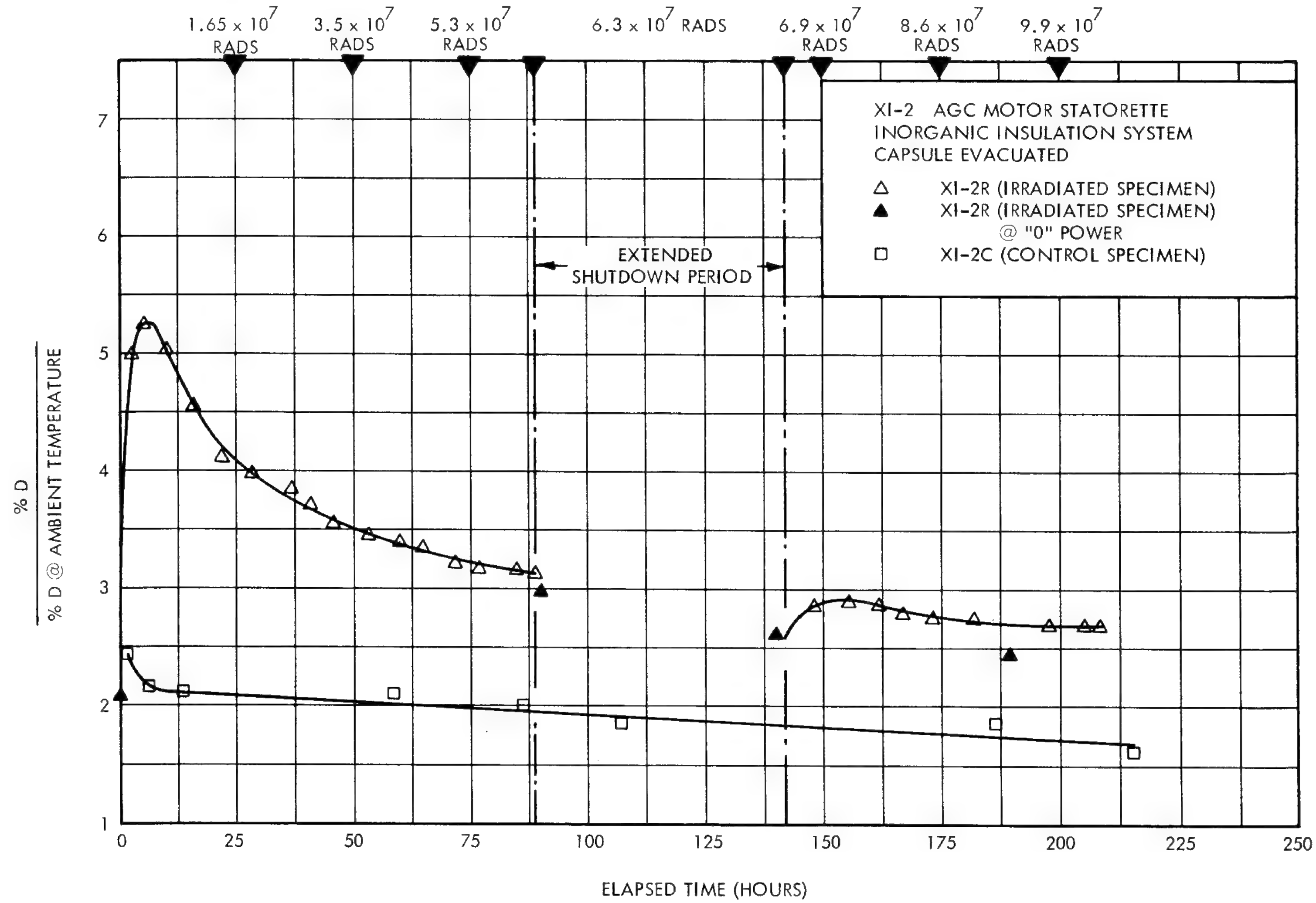


FIGURE 11-7 DISSIPATION FACTOR Aϕ – IRON XI-2 STATORETTE

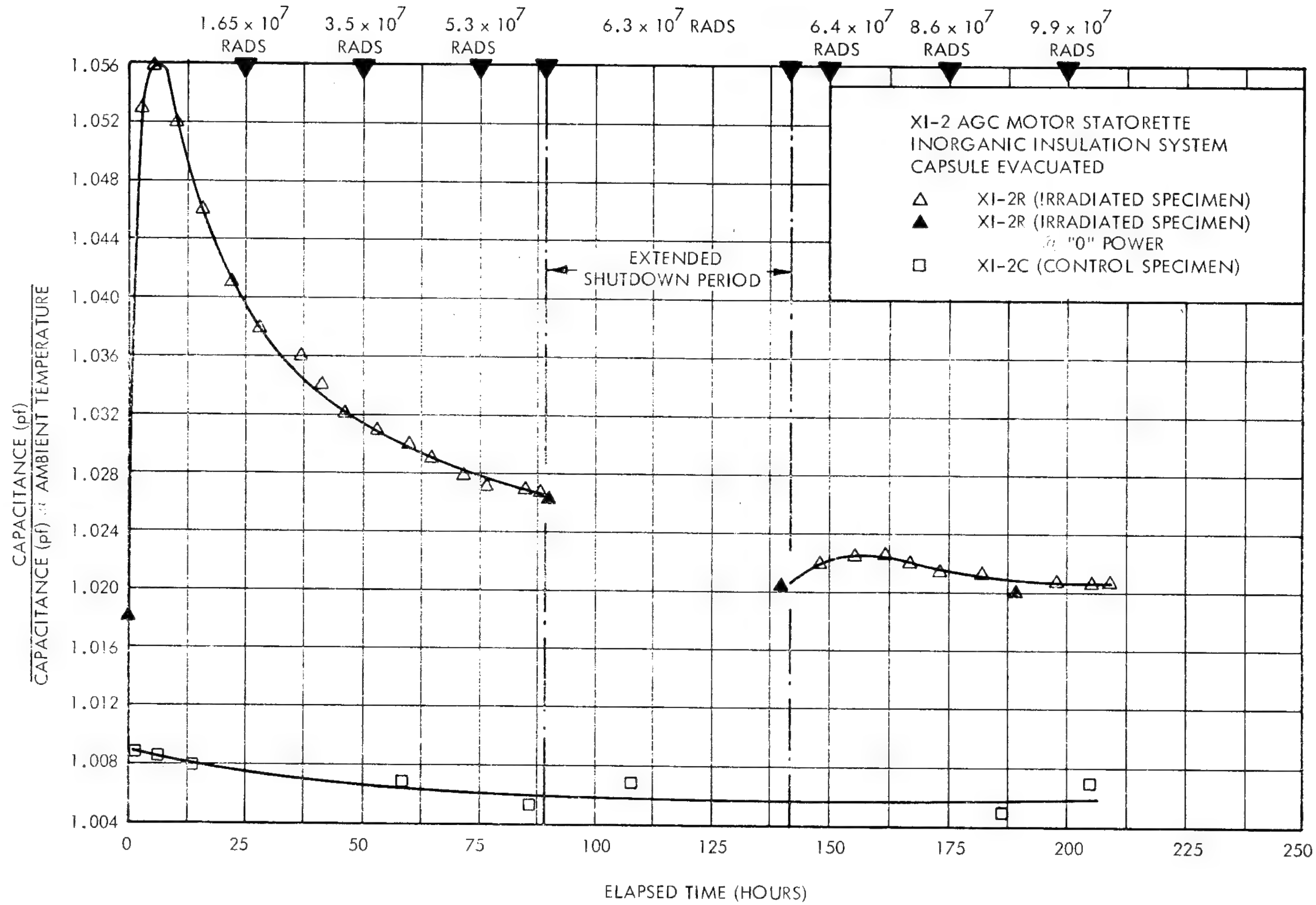


FIGURE 11-8 CAPACITANCE A ϕ - IRON XI-2 STATORETTE

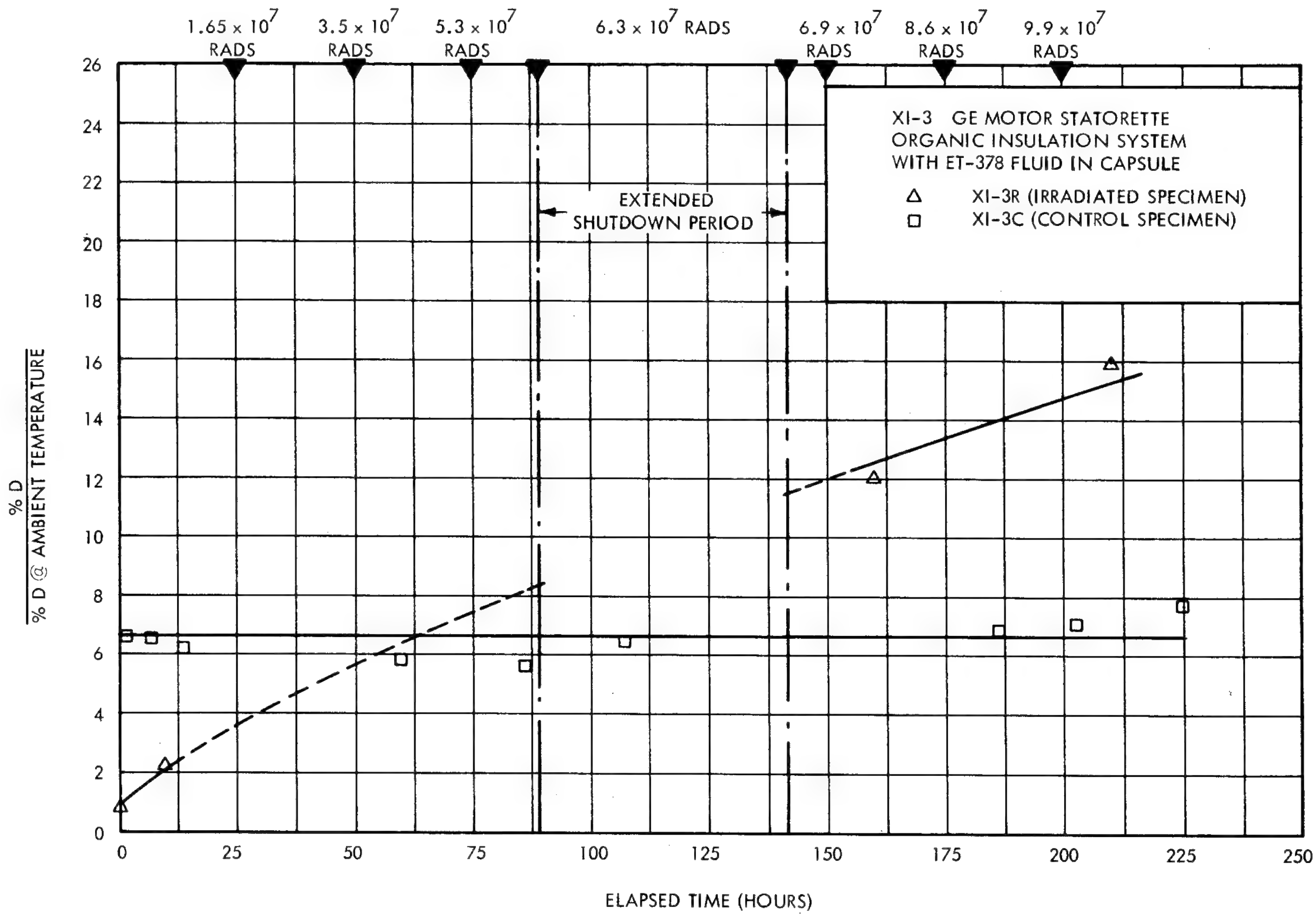


FIGURE 11-9 DISSIPATION A ϕ – B ϕ XI-3 STATORETTE

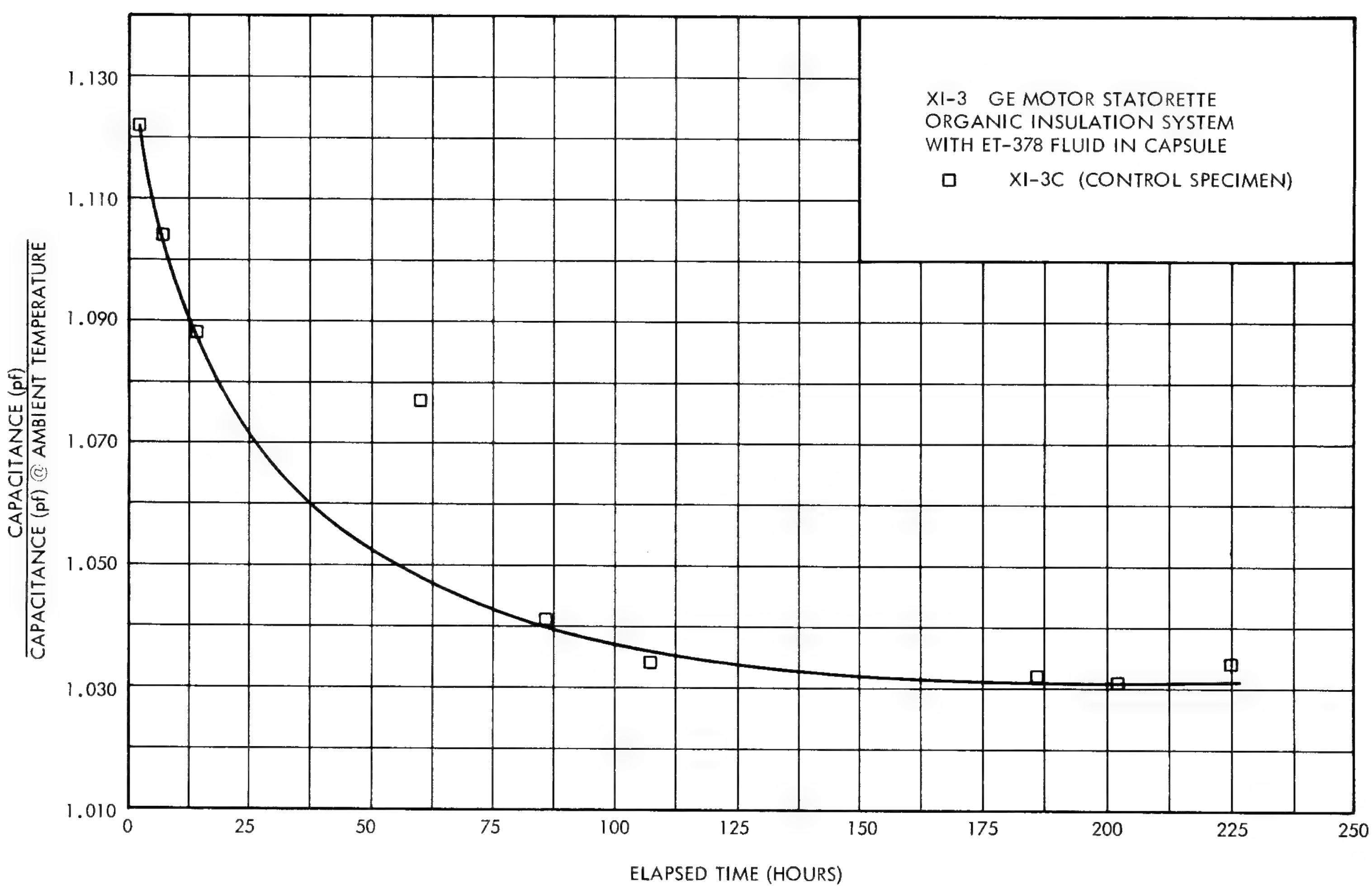


FIGURE 11-10 CAPACITANCE A ϕ – B ϕ XI-3 STATORETTE

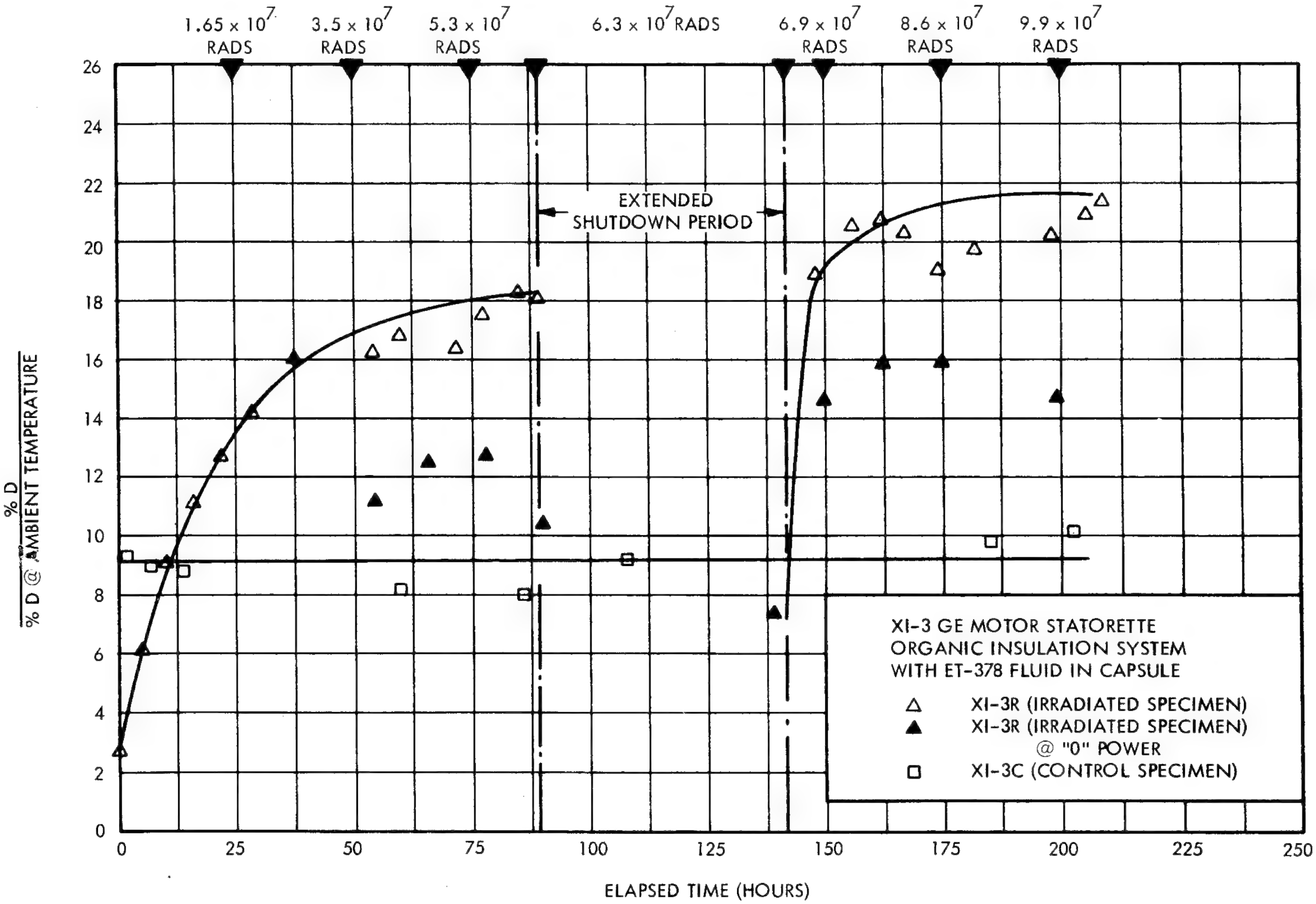


FIGURE 11-11 DISSIPATION FACTOR Aϕ - IRON XI-3 STATORETTE

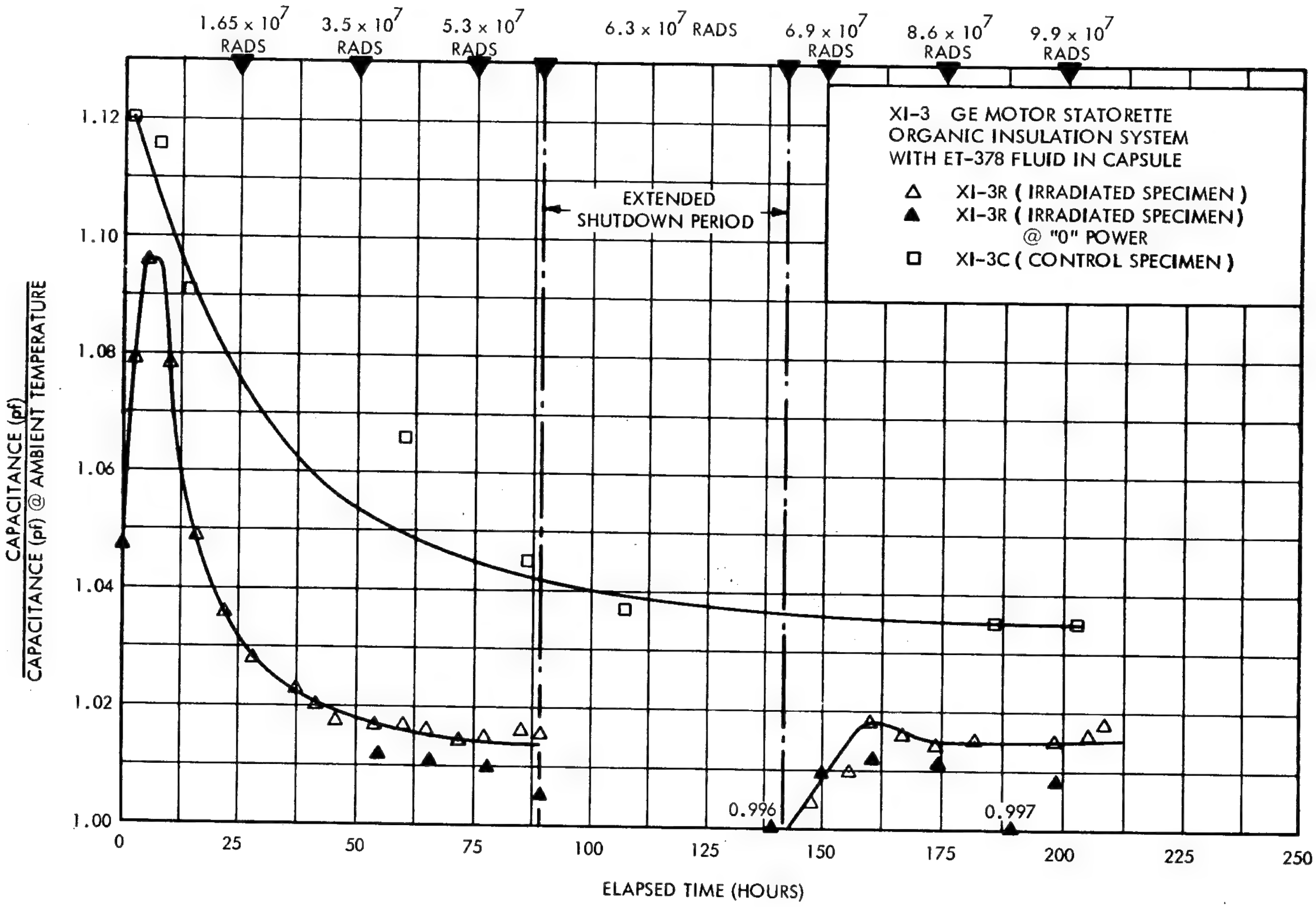


FIGURE 11-12 CAPACITANCE A ϕ – IRON XI-3 STATORETTE

FIGURE II-13 STATORETTE CAPSULE, XI-1 AND XI-2 TYPE

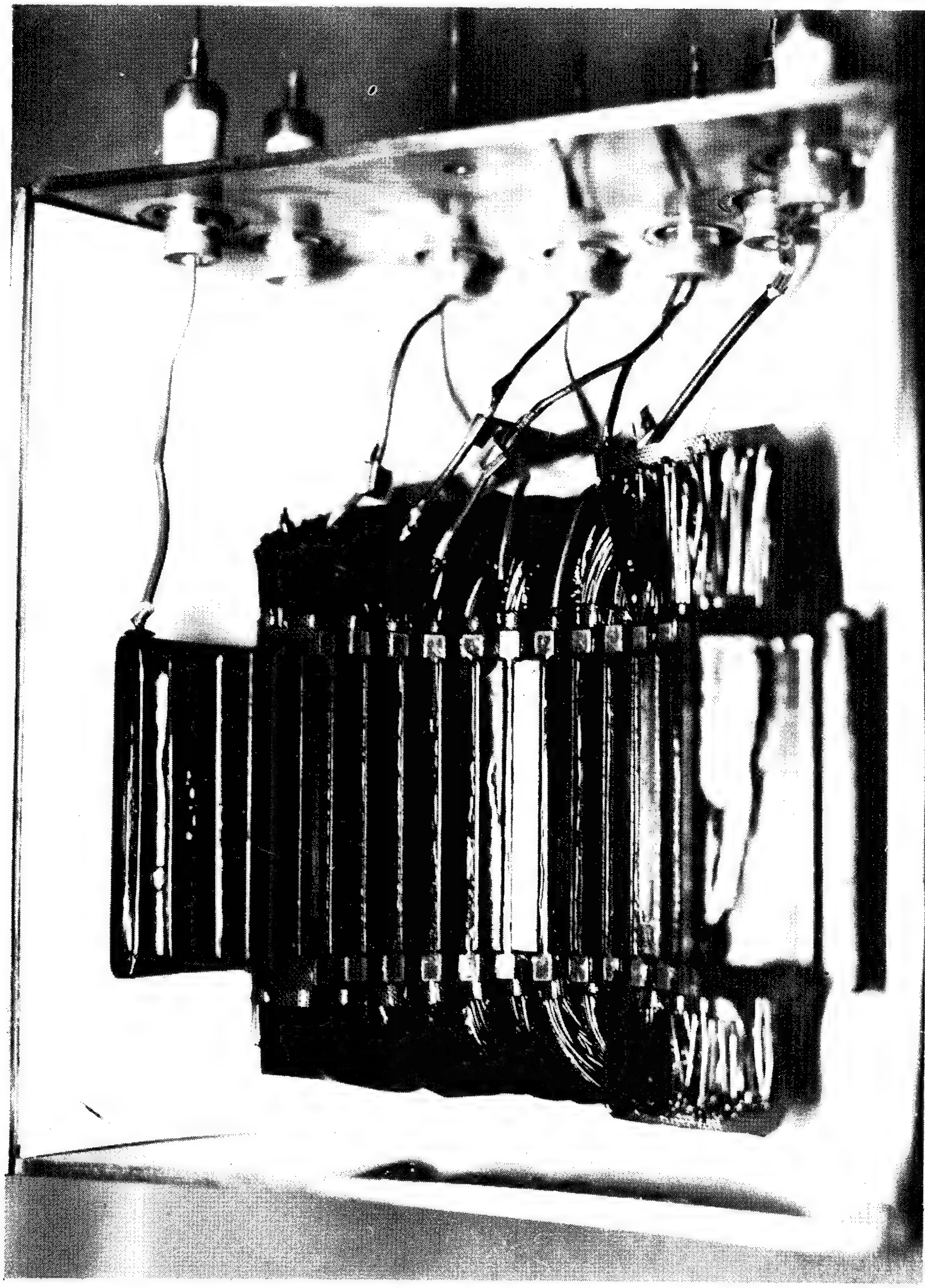


FIGURE 11-14 XI-1R STATORETTE PRIOR TO CLOSURE

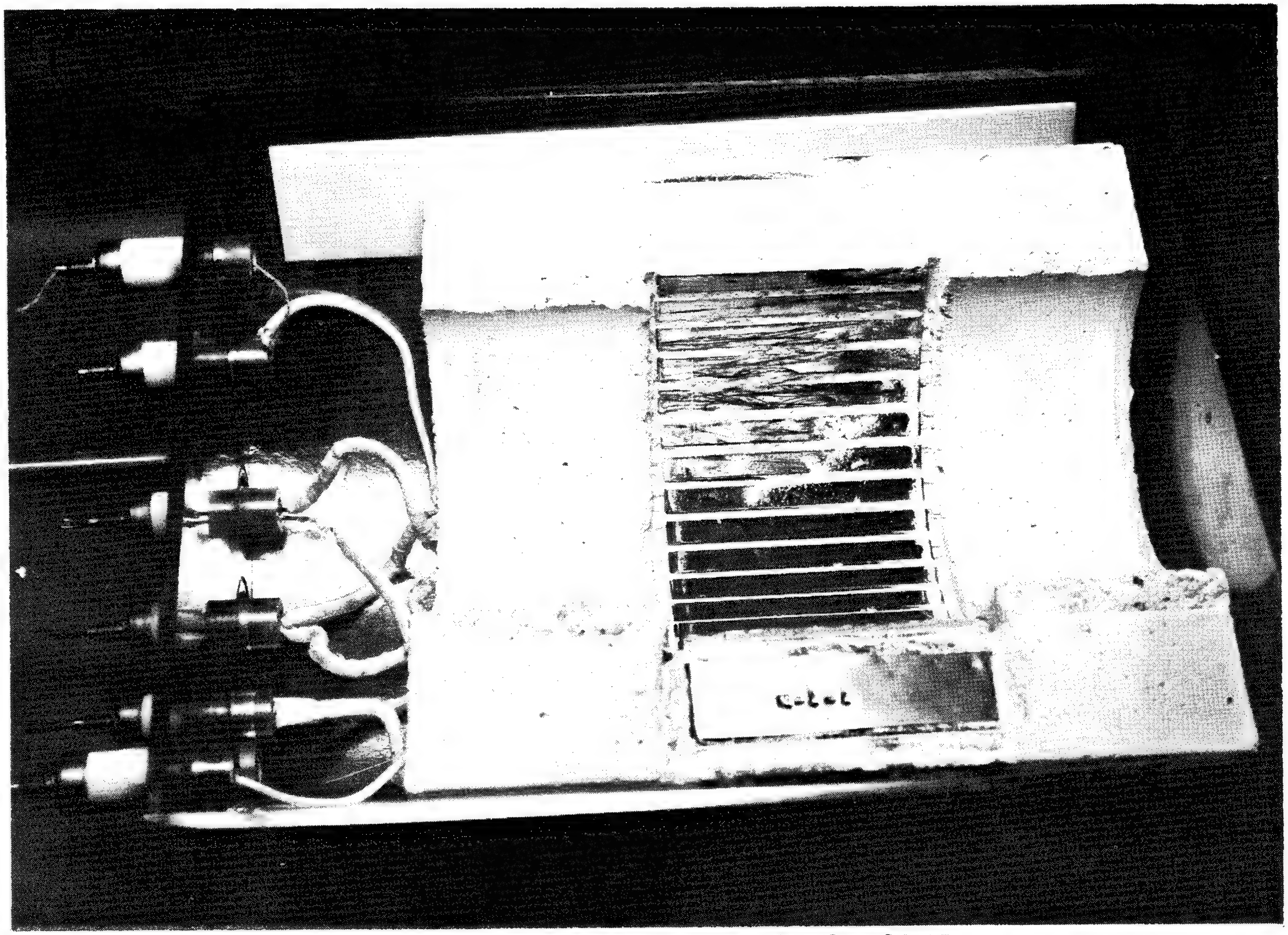


FIGURE 11-15 XI-2R, STATORETTE PRIOR TO CLOSURE

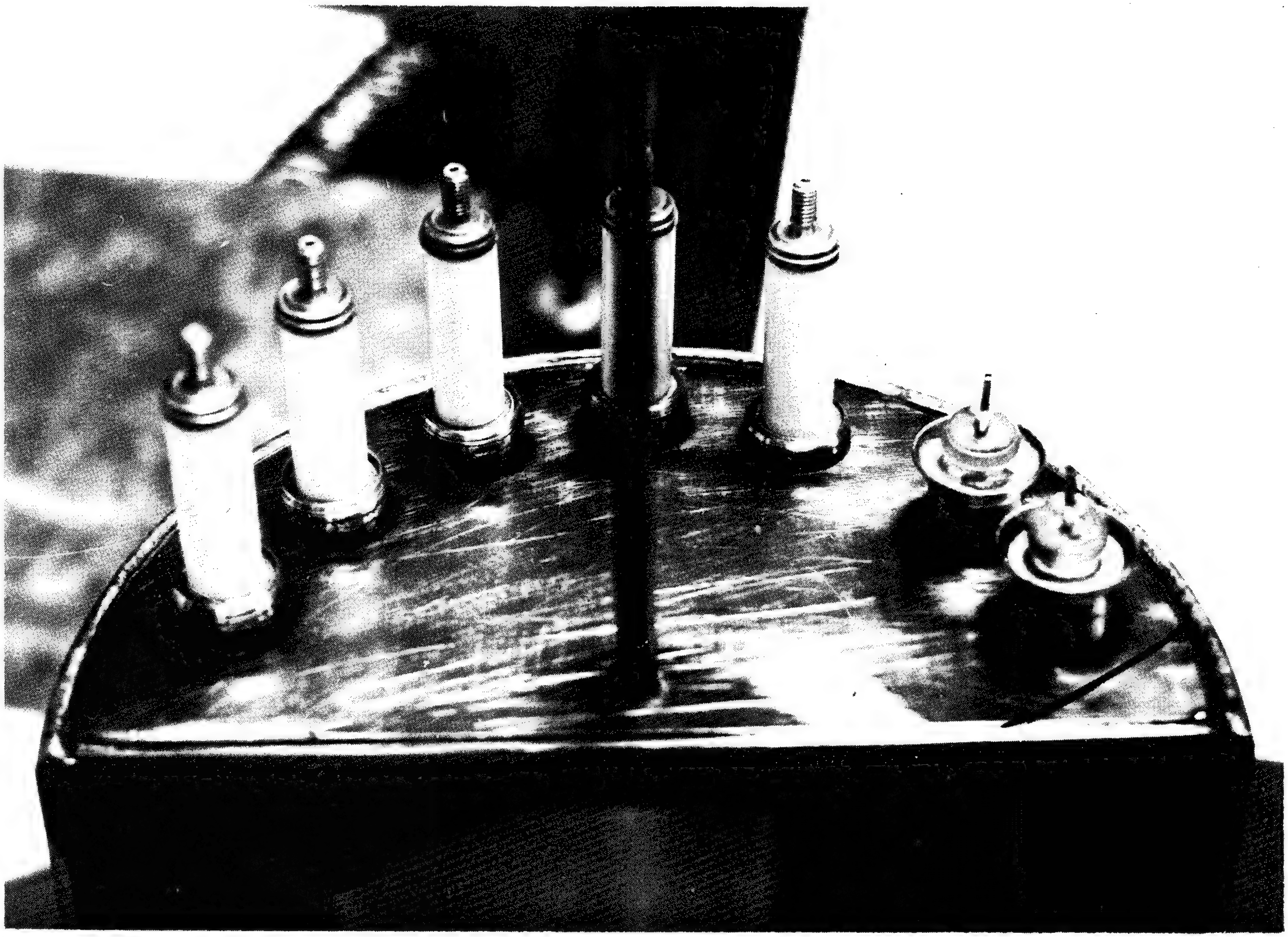


FIGURE 11-16 XI-1C AND XI-2C TERMINAL HEADER

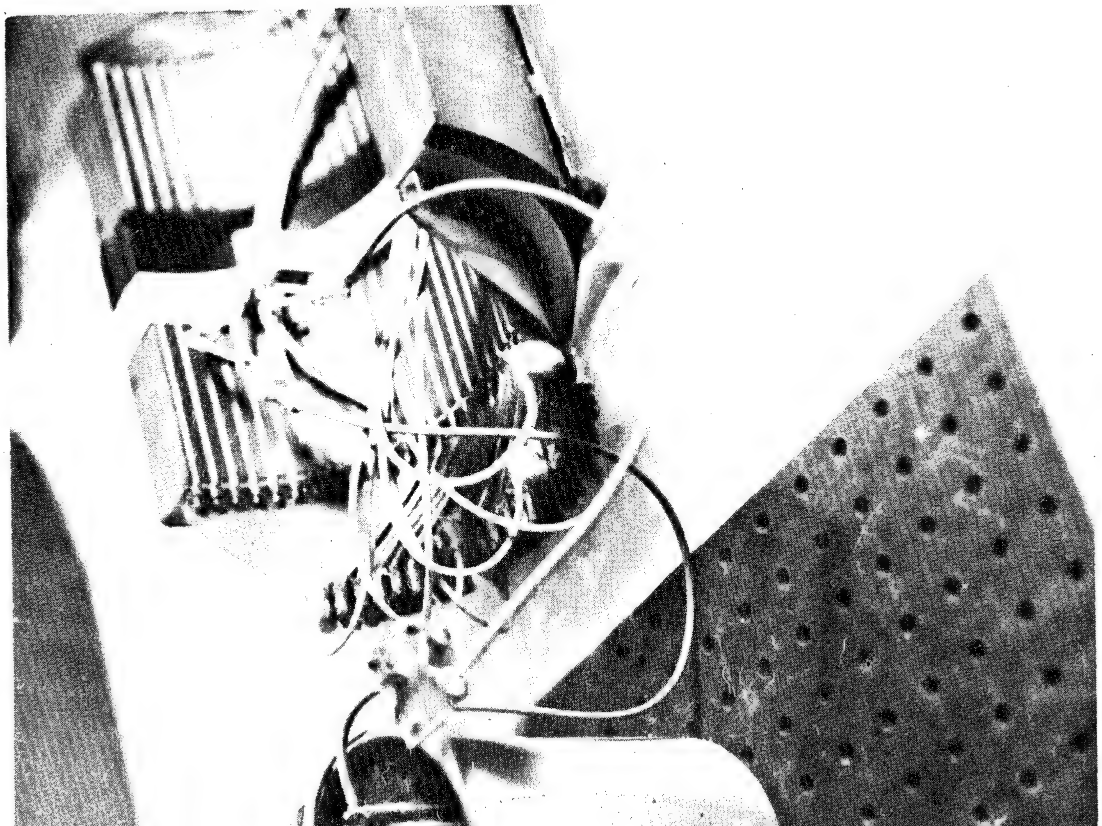


FIGURE 11-17 AC PROOF TEST

FIGURE 11-18 POST IRRADIATION STATORETTE TEST SETUP

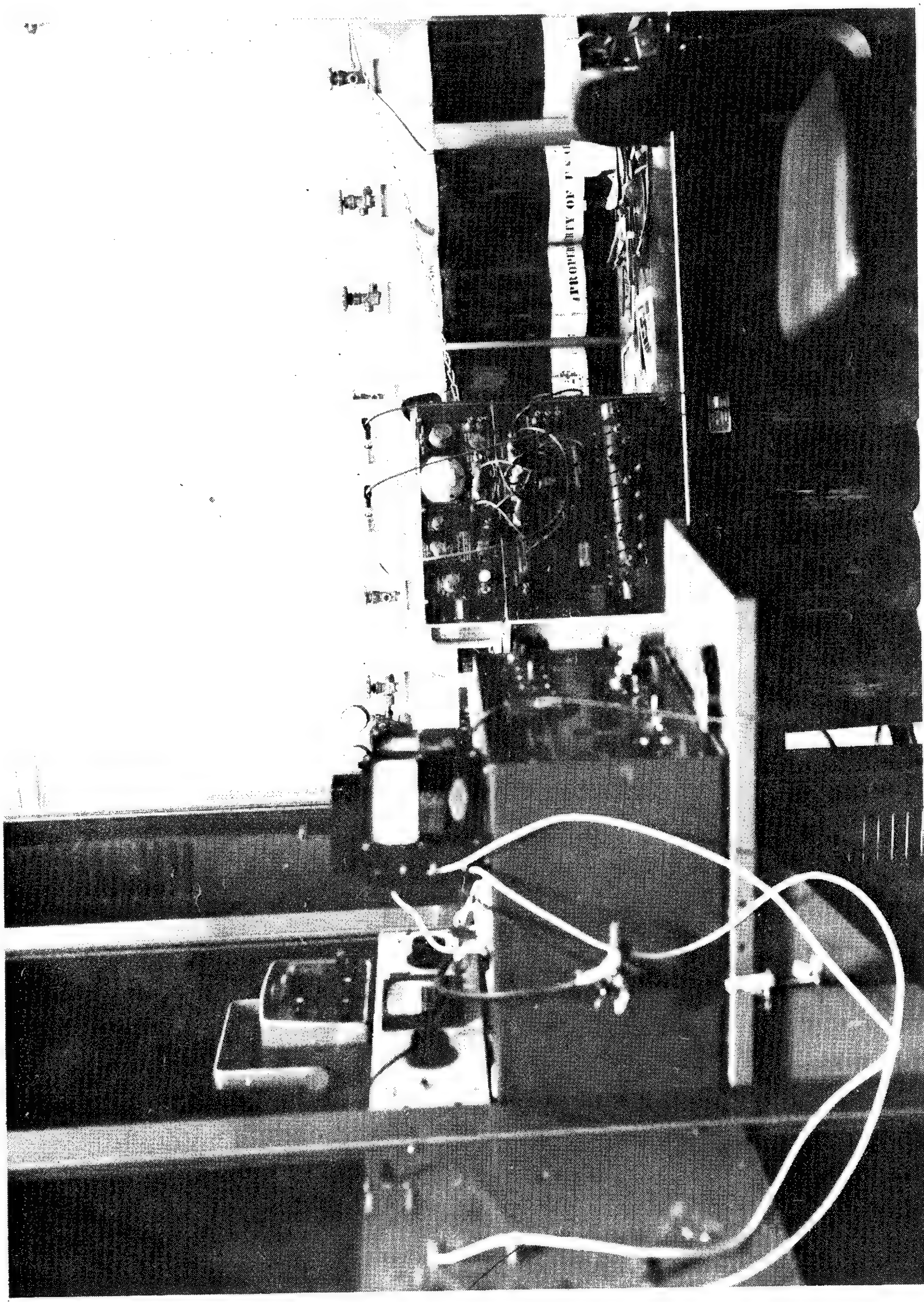


FIGURE 11-19 STATORETTE TEST EQUIPMENT AT RER

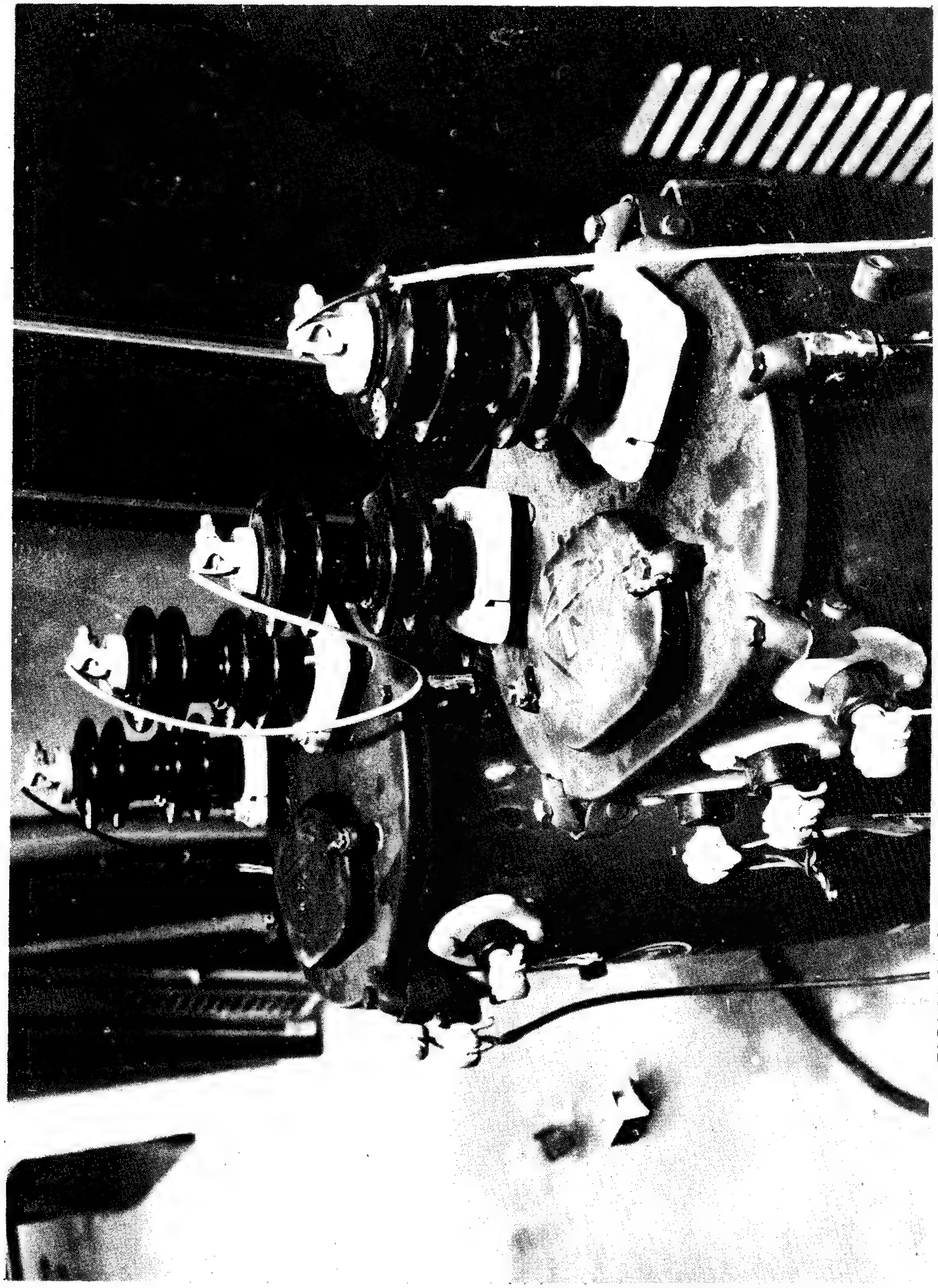


FIGURE 11-20 TRANSFORMERS FOR STATORETTE DIELECTRIC STRENGTH TESTS

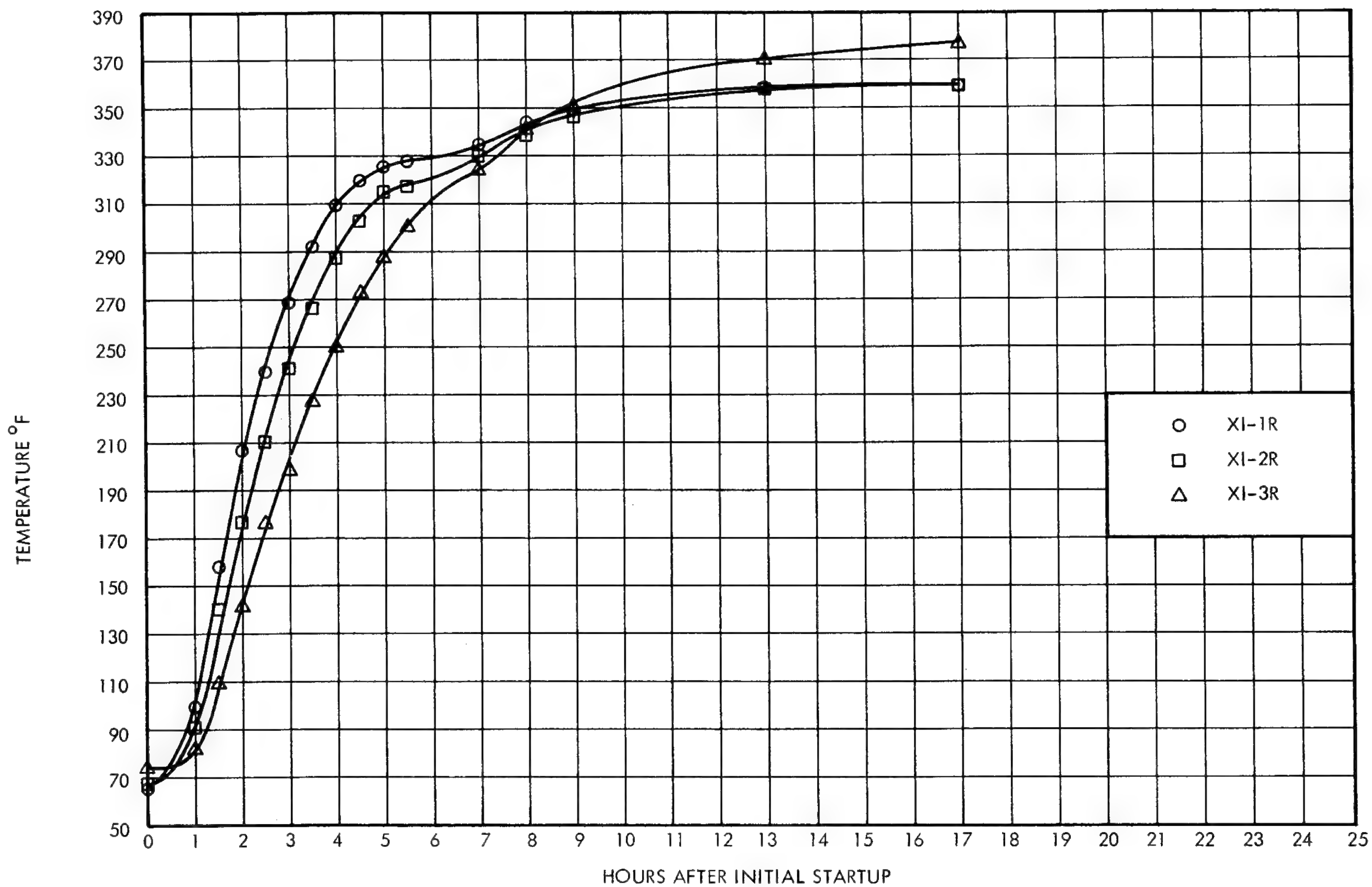


FIGURE 11-21 IRRADIATED STATORETTES - TEMPERATURE RISE OF IRON

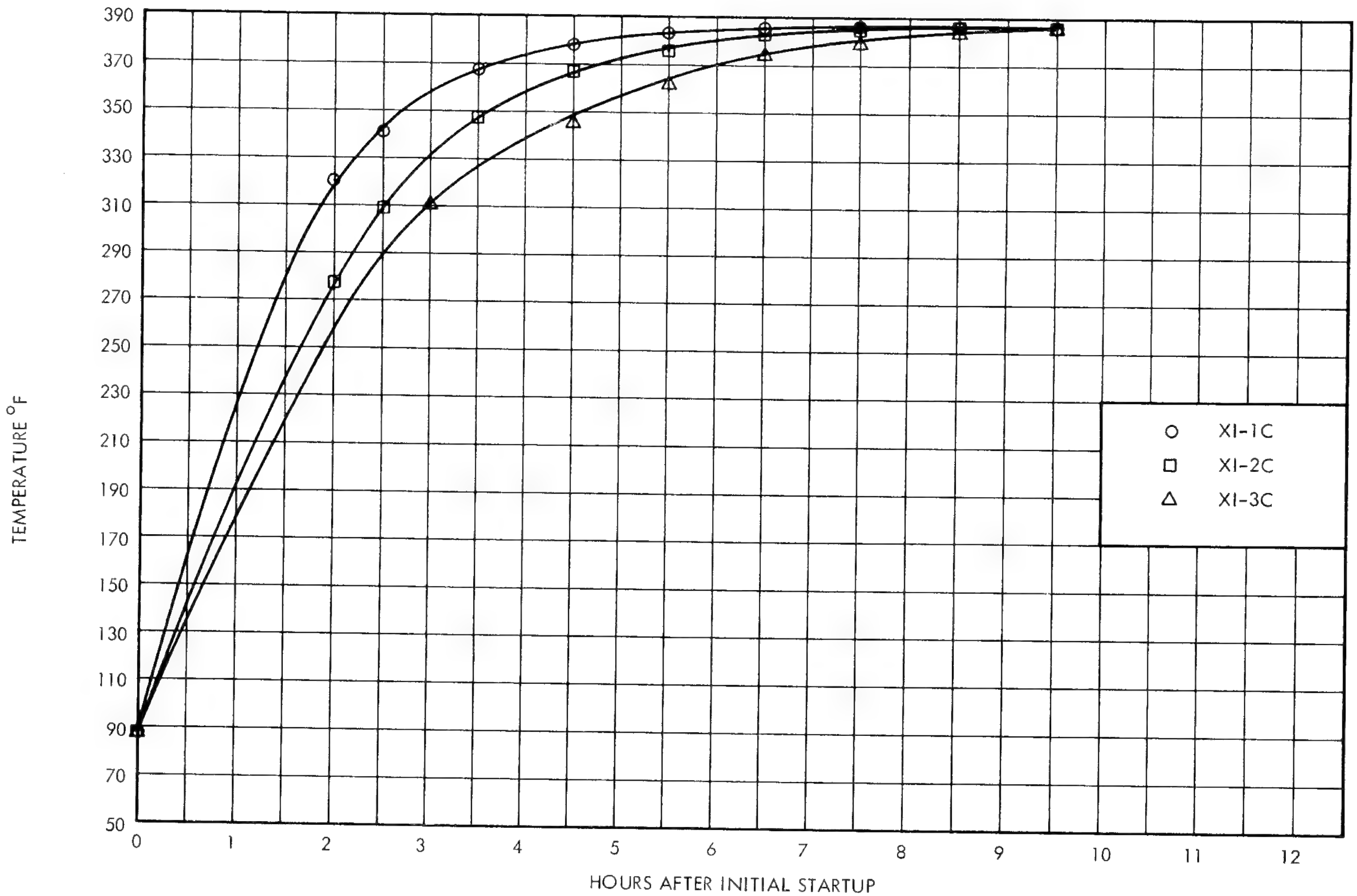


FIGURE 11-22 CONTROL STATORETTES - TEMPERATURE RISE OF IRON

TABLE 11-1

CONDITION A

(Aϕ TO Bϕ WITH Cϕ AND IRON SHORTED TO GROUND)

STATORETTE XI-1R AGC - ORGANIC INSULATION SYSTEM NITROGEN COVER GAS				
Insulation Resistance (Ω)			Gamma Dose (Rads)	Elapsed Time @ 386° F (Hours)
@250 VDC	@ 500 VDC	@ 750 VDC		
2.3×10^7	2.9×10^7	3.3×10^7	2.2×10^7	~ 29
1.8×10^7	1.9×10^7	2.0×10^7	4.1×10^7	~ 59
9.6×10^6	1.1×10^7	1.2×10^7	6.3×10^7	~ 90
3.8×10^6	3.9×10^6	4.2×10^6	8.6×10^7	~174
2.8×10^6	3.1×10^6	3.4×10^6	9.6×10^7	~196
2.5×10^6	2.8×10^6	2.9×10^6	1.07×10^8	~211

STATORETTE XI-2R AGC - INORGANIC INSULATION SYSTEM CAPSULE EVACUATED				
Insulation Resistance (Ω)			Gamma Dose (Rads)	Elapsed Time @ 386° F (Hours)
@250 VDC	@ 500 VDC	@ 750 VDC		
2.3×10^9	2.6×10^9	2.9×10^9	2.4×10^7	~ 39
2.5×10^9	2.9×10^9	3.1×10^9	4.0×10^7	~ 61
2.5×10^9	2.9×10^9	3.3×10^9	6.2×10^7	~ 90
2.7×10^9	3.3×10^9	3.6×10^9	8.4×10^7	~178
2.5×10^9	3.1×10^9	3.4×10^9	9.2×10^7	~189
2.5×10^9	3.1×10^9	3.4×10^9	1.04×10^8	~211

STATORETTE XI-3R GE - ORGANIC INSULATION SYSTEM WITH ET-378 IN CAPSULE				
Insulation Resistance (Ω)			Gamma Dose (Rads)	Elapsed Time @ 386° F (Hours)
@ 250 VDC	@500 VDC	@ 750 VDC		
5.0×10^8	6.1×10^8	6.3×10^8	2.4×10^7	~ 39
4.9×10^8	6.0×10^8	6.2×10^8	4.0×10^7	~ 61
4.5×10^8	5.6×10^8	6.3×10^8	6.2×10^7	~ 90
4.3×10^8	5.4×10^8	5.8×10^8	8.4×10^7	~178
4.0×10^8	5.0×10^8	5.4×10^8	9.7×10^7	~203
3.9×10^8	5.0×10^8	5.4×10^8	1.05×10^8	~215

TABLE 11-2

CONDITION A

(Aϕ TO Bϕ WITH Cϕ AND IRON SHORTED TO GROUND)

STATORETTE XI-1C AGC - ORGANIC INSULATION SYSTEM NITROGEN COVER GAS

Insulation Resistance (Ω)			Elapsed Time
@250 VDC	@ 500 VDC	@ 750 VDC	@ 386° F
1.5×10^{10}	1.1×10^{10}	1.0×10^{10}	Pre-Test @ Ambient Temperature
2.1×10^{6}	2.6×10^{6}	2.9×10^{6}	~ 0 Hours
2.5×10^{6}	2.8×10^{6}	3.1×10^{6}	~ 3 Hours
2.1×10^{6}	2.8×10^{6}	3.1×10^{6}	~ 8 Hours

STATORETTE XI-2C AGC - INORGANIC INSULATION SYSTEM CAPSULE EVACUATED

Insulation Resistance (Ω)			Elapsed Time
@ 250 VDC	@ 500 VDC	@ 750 VDC	@ 386° F
2.8×10^{13}	2.9×10^{13}	3.4×10^{13}	@ Ambient Temperature
5.1×10^{11}	2.3×10^{11}	2.0×10^{11}	~ 0 Hours
2.1×10^{11}	1.7×10^{11}	1.8×10^{11}	~ 3.5 Hours
1.2×10^{11}	1.5×10^{11}	1.5×10^{11}	~ 57 Hours
1.6×10^{11}	1.9×10^{11}	1.9×10^{11}	~ 84 Hours
2.1×10^{11}	2.1×10^{11}	2.0×10^{11}	~227 Hours

STATORETTE XI-3C GE - ORGANIC INSULATION SYSTEM WITH ET-378 IN CAPSULE

Insulation Resistance (Ω)			Elapsed Time
@ 250 VDC	@ 500 VDC	@ 750 VDC	@ 386° F
2.8×10^{10}	5.5×10^{10}	7.5×10^{10}	@ Ambient Temperature
3.4×10^{8}	3.3×10^{8}	3.4×10^{8}	~ 0 Hours
3.7×10^{8}	3.8×10^{8}	3.7×10^{8}	~ 4 Hours
8.3×10^{8}	8.8×10^{8}	9.1×10^{8}	~ 131 Hours
9.3×10^{8}	8.9×10^{8}	9.2×10^{8}	~ 161 Hours
7.3×10^{8}	7.7×10^{8}	7.8×10^{8}	~ 227 Hours

TABLE 11-3

CONDITION B

(Bϕ TO Cϕ WITH Aϕ AND IRON SHORTED TO GROUND)

STATORETTE XI-1R AGC - ORGANIC INSULATION SYSTEM NITROGEN COVER GAS				
Insulation Resistance (Ω)			Gamma Dose (Rads)	Elapsed Time @ 386° F (Hours)
@ 250 VDC	@500 VDC	@750 VDC		
2.7×10^7	3.1×10^7	3.0×10^7	2.2×10^7	~ 29
1.8×10^7	1.9×10^7	2.0×10^7	4.1×10^7	~ 59
1.0×10^7	1.1×10^7	1.2×10^7	6.3×10^7	~ 90
4.6×10^6	4.5×10^6	4.2×10^7	8.6×10^7	~174
3.5×10^6	3.3×10^6	3.3×10^7	9.6×10^7	~196
3.0×10^6	2.9×10^6	2.9×10^7	1.07×10^8	~211

STATORETTE XI-2R AGC - INORGANIC INSULATION SYSTEM CAPSULE EVACUATED				
Insulation Resistance (Ω)			Gamma Dose (Rads)	Elapsed Time @ 386° F (Hours)
@ 250 VDC	@ 500 VDC	@ 750 VDC		
1.9×10^9	2.2×10^9	2.3×10^9	2.4×10^7	~ 39
2.1×10^9	2.5×10^9	2.7×10^9	4.0×10^7	~ 61
2.1×10^9	2.5×10^9	2.9×10^9	6.2×10^7	~ 90
2.3×10^9	2.8×10^9	3.1×10^9	8.4×10^7	~178
2.5×10^9	2.8×10^9	3.1×10^9	9.2×10^7	~189
2.5×10^9	2.8×10^9	3.1×10^9	1.04×10^8	~211

STATORETTE XI-3R GE - ORGANIC INSULATION SYSTEM WITH ET-378 IN CAPSULE				
Insulation Resistance (Ω)			Gamma Dose (Rads)	Elapsed Time @ 386° F (Hours)
@ 250 VDC	@ 500 VDC	@ 750 VDC		
5.4×10^8	6.6×10^8	7.5×10^8	2.4×10^7	~ 39
5.1×10^8	6.6×10^8	6.8×10^8	4.0×10^7	~ 61
4.9×10^8	6.3×10^8	7.5×10^8	6.2×10^7	~ 90
4.4×10^8	5.7×10^8	6.8×10^8	8.4×10^7	~178
3.9×10^8	5.2×10^8	5.8×10^8	9.7×10^7	~203
4.2×10^8	5.3×10^8	6.2×10^8	1.05×10^8	~215

TABLE 11-4

CONDITION B

(Bϕ TO C ϕ WITH Aϕ AND IRON SHORTED TO GROUND)

STATORETTE XI-1C AGC - ORGANIC INSULATION SYSTEM NITROGEN COVER GAS

Insulation Resistance (Ω)			Elapsed Time @ 386° F
@ 250 VDC	@ 500 VDC	@ 750 VDC	
2.8×10^9	5.4×10^9	8.0×10^9	Pre-Test @ Ambient Temperature
3.3×10^6	3.6×10^6	3.7×10^6	~ 0 Hours
3.6×10^6	4.0×10^6	4.4×10^6	~ 3 Hours
4.0×10^6	4.2×10^6	4.7×10^6	~ 8 Hours
3.5×10^6	3.6×10^6	3.6×10^6	~ 84 Hours
3.3×10^6	3.6×10^6	3.6×10^6	~ 227 Hours

STATORETTE XI-2C AGC - INORGANIC INSULATION SYSTEM CAPSULE EVACUATED

Insulation Resistance (Ω)			Elapsed Time @ 386° F
@ 250 VDC	@ 500 VDC	@ 750 VDC	
1.1×10^{12}	3.6×10^{12}	7.5×10^{12}	@ Ambient Temperature
5.7×10^{10}	7.3×10^{10}	6.8×10^{10}	~ 0 Hours
2.1×10^{10}	2.4×10^{10}	2.9×10^{10}	~ 3.5 Hours
7.8×10^{10}	7.0×10^{10}	5.8×10^{10}	~ 57 Hours
8.1×10^{10}	8.3×10^{10}	8.2×10^{10}	~ 84 Hours
1.5×10^{11}	9.3×10^{10}	8.5×10^{10}	~ 227 Hours

STATORETTE XI-3C GE - ORGANIC INSULATION SYSTEM WITH ET-378 IN CAPSULE

Insulation Resistance (Ω)			Elapsed Time @ 386° F
@ 250 VDC	@ 500 VDC	@ 750 VDC	
2.7×10^{12}	6.3×10^{12}	9.4×10^{12}	@ Ambient Temperature
3.7×10^8	3.6×10^8	3.4×10^8	~ 0 Hours
3.0×10^8	3.3×10^8	3.4×10^8	~ 4 Hours
7.1×10^8	7.5×10^8	8.3×10^8	~ 131 Hours
7.4×10^8	7.5×10^8	7.8×10^8	~ 161 Hours
6.3×10^8	6.3×10^8	6.2×10^8	~ 227 Hours

TABLE 11-5

CONDITION C

(Cϕ TO Aϕ WITH Bϕ AND IRON SHORTED TO GROUND)

STATORETTE XI-1R AGC - ORGANIC INSULATION SYSTEM NITROGEN COVER GAS

Insulation Resistance (Ω)			Gamma Dose (Rads)	Elapsed Time @386° F (Hours)
@250 VDC	@ 500 VDC	@750 VDC		
4.5×10^7	5.0×10^7	5.4×10^7	2.2×10^7	~ 29
3.0×10^7	3.3×10^7	3.4×10^7	4.1×10^7	~ 59
1.8×10^7	1.9×10^7	2.0×10^7	6.3×10^7	~ 90
7.4×10^6	6.9×10^7	6.2×10^6	8.6×10^7	~ 174
5.4×10^6	5.2×10^6	5.0×10^6	9.6×10^7	~ 196
4.9×10^6	4.5×10^6	4.7×10^6	1.07×10^8	~ 211

STATORETTE XI-2R AGC - INORGANIC INSULATION SYSTEM CAPSULE EVACUATED

Insulation Resistance (Ω)			Gamma Dose (Rads)	Elapsed Time @ 386° F (Hours)
@ 250 VDC	@ 500 VDC	@ 750 VDC		
3.8×10^9	4.5×10^9	5.0×10^9	2.4×10^7	~ 39
4.3×10^9	5.4×10^9	6.2×10^9	4.0×10^7	~ 61
4.6×10^9	6.0×10^9	6.8×10^9	6.2×10^7	~ 90
5.4×10^9	7.0×10^9	7.8×10^9	8.4×10^7	~178
5.4×10^9	6.9×10^9	7.6×10^9	9.7×10^7	~203
4.7×10^9	6.6×10^9	7.5×10^9	1.04×10^8	~211

STATORETTE XI-3R GE - ORGANIC INSULATION SYSTEM WITH ET-378 IN CAPSULE

Insulation Resistance (Ω)			Gamma Dose (Rads)	Elapsed Time @ 386° F (Hours)
@ 250 VDC	@ 500 VDC	@ 750 VDC		
9.6×10^8	1.1×10^9	1.1×10^9	2.4×10^7	~ 39
1.0×10^9	1.2×10^9	1.3×10^9	4.0×10^7	~ 61
1.0×10^9	1.2×10^9	1.3×10^9	6.2×10^7	~ 90
1.0×10^9	1.2×10^9	1.3×10^9	8.4×10^7	~178
9.3×10^8	1.1×10^9	1.2×10^9	9.7×10^7	~203
8.9×10^8	1.1×10^9	1.2×10^9	1.05×10^8	~215

TABLE 11-6

CONDITION C

(Cϕ TO Aϕ WITH Bϕ AND IRON SHORTED TO GROUND)

STATORETTE XI-1C AGC - ORGANIC INSULATION SYSTEM NITROGEN COVER GAS

Insulation Resistance (Ω)			Elapsed Time @ 386° F
@ 250 VDC	@ 500 VDC	@ 750 VDC	
1.1×10^{10}	8.9×10^{9}	8.2×10^{9}	Pre-Test @ Ambient Temperature
2.3×10^{6}	2.6×10^{6}	2.9×10^{6}	~ 0 Hours
2.5×10^{6}	4.0×10^{6}	4.4×10^{6}	~ 3 Hours
2.8×10^{6}	3.1×10^{6}	3.4×10^{6}	~ 8 Hours
1.1×10^{6}	3.6×10^{6}	3.4×10^{6}	~ 84 Hours
1.1×10^{6}	2.2×10^{6}	3.6×10^{6}	~ 227 Hours

STATORETTE XI-2C AGC - INORGANIC INSULATION SYSTEM CAPSULE EVACUATED

Insulation Resistance (Ω)			Elapsed Time @ 386° F
@ 250 VDC	@ 500 VDC	@ 750 VDC	
1.0×10^{12}	3.1×10^{12}	$6.2 \text{ z } 10^{12}$	@ Ambient Temperature
7.8×10^{10}	1.2×10^{11}	1.2×10^{11}	~ 0 Hours
4.9×10^{10}	3.1×10^{10}	3.1×10^{10}	~ 3.5 Hours
2.3×10^{10}	2.8×10^{10}	2.8×10^{10}	~ 57 Hours
5.0×10^{10}	9.8×10^{10}	1.1×10^{11}	~ 84 Hours
4.6×10^{10}	8.9×10^{10}	1.1×10^{11}	~ 227 Hours

STATORETTE XI-3C GE - ORGANIC INSULATION SYSTEM CAPSULE EVACUATED

Insulation Resistance (Ω)			Elapsed Time @ 386° F
@ 250 VDC	@ 500 VDC	@ 750 VDC	
4.2×10^{12}	1.0×10^{13}	9.4×10^{11}	@ Ambient Temperature
4.3×10^{8}	4.2×10^{8}	4.4×10^{8}	~ 0 Hours
5.4×10^{8}	5.4×10^{8}	5.4×10^{8}	~ 4 Hours
1.1×10^{9}	1.1×10^{9}	1.1×10^{9}	~ 131 Hours
1.1×10^{9}	1.1×10^{9}	1.1×10^{9}	~ 161 Hours
8.9×10^{8}	9.3×10^{8}	9.6×10^{8}	~ 227 Hours

TABLE 11-7

CONDITION D AND D'

(Aϕ TO IRON D- Bϕ AND Cϕ SHORTED TO IRON, D' - Bϕ AND Cϕ SHORTED TO GROUND)

STATORETTE XI-1R AGC - ORGANIC INSULATION SYSTEM NITROGEN COVER GAS

Insulation Resistance (Ω)			Gamma Dose (Rads)	Elapsed Time @ 386° F (Hours)
@ 250 VDC	@ 500 VDC	@ 750 VDC		
1.3×10^7	1.4×10^7	1.6×10^7	3.4×10^6	~ 7
3.5×10^6	3.3×10^6	2.9×10^6	2.4×10^7	~ 38
2.5×10^6	2.3×10^6	1.9×10^6	4.1×10^7	~ 59
*2.1×10^6	1.9×10^6	1.6×10^6	6.3×10^7	~ 90
*1.6×10^6	1.5×10^6	1.2×10^6	8.6×10^7	~174
*1.6×10^6	1.4×10^6	1.0×10^6	1.07×10^8	~211

STATORETTE XI-2R AGC - INORGANIC INSULATION SYSTEM CAPSULE EVACUATED

Insulation Resistance (Ω)			Gamma Dose (Rads)	Elapsed Time @ 386° F (Hours)
@ 250 VDC	@500 VDC	@ 750 VDC		
4.5×10^8	4.5×10^8	4.7×10^8	3.3×10^6	~ 9
6.6×10^8	7.1×10^8	6.8×10^8	2.3×10^7	~ 38
7.8×10^8	8.8×10^8	8.7×10^8	4.0×10^7	~ 61
*1.8×10^9	1.9×10^9	1.8×10^9	6.2×10^7	~ 90
*2.1×10^9	2.4×10^9	2.3×10^9	8.4×10^7	~178
*2.1×10^9	2.3×10^9	2.3×10^9	$1.04 \times 10^{*}$	~211

STATORETTE XI-3R GE - ORGANIC INSULATION SYSTEM WITH ET-378 IN CAPSULE

Insulation Resistance (Ω)			Gamma Dose (Rads)	Elapsed Time @ 386° F (Hours)
@ 250 VDC	@ 500 VDC	@ 750 VDC		
5.3×10^7	5.4×10^7	5.4×10^7	3.3×10^6	~ 9
6.3×10^7	6.1×10^7	5.4×10^7	2.4×10^7	~ 39
6.9×10^7	7.1×10^7	6.2×10^7	4.0×10^7	~ 61
*8.6×10^7	8.6×10^7	7.5×10^7	6.2×10^7	~ 90
*8.1×10^7	8.2×10^7	7.5×10^7	8.4×10^7	~178
*7.4×10^7	7.4×10^8	6.8×10^7	1.04×10^8	~211

*D'

TABLE 11-8

CONDITION D'

(A ϕ TO IRON WITH Bϕ AND Cϕ SHORTED TO GROUND)

STATORETTE XI-1C AGC - ORGANIC INSULATION SYSTEM NITROGEN COVER GAS

Insulation Resistance (Ω)			Elapsed Time
@ 250 VDC	@ 500 VDC	@ 750 VDC	@ 386° F
3.6×10^9	1.9×10^9	1.8×10^9	Pre-Test @ Ambient Temperature
5.0×10^5	5.0×10^5	7.5×10^5	~ 0 Hours
5.2×10^5	5.5×10^5	@ 560 VDC 5.6×10^5	~ 3 Hours
6.0×10^5	6.2×10^5	@ 660 VDC 6.6×10^5	~ 8 Hours

STATORETTE XI-2C AGC - INORGANIC INSULATION SYSTEM CAPSULE EVACUATED

Insulation Resistance (Ω)			Elapsed Time
@ 250 VDC	@ 500 VDC	@ 750 VDC	@ 386° F
6.2×10^{12}	8.3×10^{12}	6.2×10^{12}	@ Ambient Temperature
2.3×10^{10}	2.4×10^{10}	2.3×10^{10}	~ 0 Hours
1.8×10^{10}	2.2×10^{10}	2.1×10^{10}	~ 3.5 Hours
1.9×10^{10}	1.8×10^{10}	1.9×10^{10}	~ 57 Hours
3.2×10^{10}	2.9×10^{10}	2.8×10^{10}	~ 84 Hours
3.0×10^{10}	3.1×10^{10}	2.9×10^{10}	~ 227 Hours

STATORETTE XI-3C GE - ORGANIC INSULATION SYSTEM WITH ET-378 IN CAPSULE

Insulation Resistance (Ω)			Elapsed Time
@ 250 VDC	@ 500 VDC	@ 750 VDC	@ 386° F
1.7×10^{10}	3.3×10^{10}	5.0×10^{10}	@ Ambient Temperature
2.9×10^7	3.1×10^7	3.0×10^7	~ 0 Hours
2.1×10^7	2.4×10^7	2.5×10^7	~ 4 Hours
5.0×10^7	4.6×10^7	4.2×10^7	~ 131 Hours
5.3×10^7	4.5×10^7	4.4×10^7	~ 161 Hours
4.7×10^7	4.2×10^7	3.7×10^7	~ 227 Hours

TABLE 11-9

CONDITION E AND E'

(Bϕ TO IRON E - Aϕ AND Cϕ SHORTED TO IRON, E'- Aϕ AND Cϕ SHORTED TO GROUND)

STATORETTE XI-1R AGC - ORGANIC INSULATION SYSTEM NITROGEN COVER GAS

Insulation Resistance (Ω) @ 250 VDC	Insulation Resistance (Ω) @ 500 VDC	Insulation Resistance (Ω) @ 750 VDC	Gamma Dose (Rads)	Elapsed Time @ 386° F (Hours)
1.2×10^7	1.7×10^7	1.7×10^7	3.4×10^6	~ 7
3.7×10^6	3.6×10^6	3.4×10^6	2.4×10^7	~ 38
2.5×10^6	2.5×10^6	2.2×10^6	4.1×10^7	~ 59
*2.6×10^6	2.4×10^6	2.0×10^6	6.3×10^7	~ 90
*2.1×10^6	2.1×10^6	1.5×10^6	8.6×10^7	~174
*1.8×10^6	1.7×10^6	1.2×10^6	1.07×10^8	~211

STATORETTE XI-2R AGC - INORGANIC INSULATION SYSTEM CAPSULE EVACUATED

Insulation Resistance (Ω) @ 250 VDC	Insulation Resistance (Ω) @ 500 VDC	Insulation Resistance (Ω) @ 750 VDC	Gamma Dose (Rads)	Elapsed Time @ 386° F (Hours)
3.9×10^8	4.2×10^8	4.0×10^8	3.3×10^6	~ 9
5.4×10^8	6.0×10^8	5.4×10^8	2.3×10^7	~ 38
6.4×10^8	7.2×10^8	7.5×10^8	4.0×10^7	~ 61
*1.9×10^9	1.9×10^9	1.7×10^9	6.2×10^7	~ 90
*2.3×10^9	2.5×10^9	2.1×10^9	8.4×10^7	~178
*2.5×10^9	2.5×10^9	2.3×10^9	1.04×10^8	~211

STATORETTE XI-3R GE - ORGANIC INSULATION SYSTEM WITH ET-378 IN CAPSULE

Insulation Resistance (Ω) @ 250 VDC	Insulation Resistance (Ω) @ 500 VDC	Insulation Resistance (Ω) @ 750 VDC	Gamma Dose (Rads)	Elapsed Time @ 386° F (Hours)
6.1×10^7	5.8×10^7	5.8×10^7	3.3×10^6	~ 9
6.8×10^7	6.8×10^7	6.3×10^7	2.4×10^7	~ 39
7.3×10^7	7.5×10^7	6.2×10^7	4.0×10^7	~ 61
*1.0×10^8	9.8×10^7	8.1×10^7	6.2×10^7	~ 90
*1.0×10^8	9.6×10^7	7.8×10^7	8.4×10^7	~178
*8.3×10^7	8.2×10^7	7.5×10^7	1.04×10^7	~211

* E

TABLE 11-10

CONDITION E'

(Bϕ TO IRON WITH Aϕ AND Cϕ SHORTED TO GROUND)

STATORETTE XI-1C AGC - ORGANIC INSULATION SYSTEM NITROGEN COVER GAS

Insulation Resistance (Ω)			Elapsed Time
@ 250 VDC	@ 500 VDC	@ 750 VDC	@ 386° F
3.4×10^9	1.7×10^9	1.5×10^9	@ Ambient Temperature
4.0×10^5	@ 410 VDC 4.1×10^5	-----	~ 0 Hours
4.2×10^5	@ 460 VDC 4.6×10^5	-----	~ 3 Hours
3.8×10^5	@ 425 VDC 4.25×10^5	-----	~ 8 Hours
3.3×10^5	@ 350 VDC 3.5×10^5	-----	~ 84 Hours
3.8×10^5	@ 370 VDC 3.7×10^5	-----	~ 204 Hours

STATORETTE XI-2C AGC - INORGANIC INSULATION SYSTEM CAPSULE EVACUATED

Insulation Resistance (Ω)			Elapsed Time
@ 250 VDC	@ 500 VDC	@ 750 VDC	@ 386° F
2.5×10^{13}	8.3×10^{12}	9.4×10^{11}	@ Ambient Temperature
4.8×10^{10}	3.1×10^{10}	2.7×10^{10}	~ 0 Hours
4.0×10^{10}	2.9×10^{10}	2.5×10^{10}	~ 3.5 Hours
3.5×10^{10}	2.6×10^{10}	2.5×10^{10}	~ 57 Hours
4.8×10^{10}	3.6×10^{10}	3.1×10^{10}	~ 84 Hours
5.7×10^{10}	3.8×10^{10}	3.4×10^{10}	~ 227 Hours

STATORETTE XI-3C GE - ORGANIC INSULATION SYSTEM WITH ET-378 IN CAPSULE

Insulation Resistance (Ω)			Elapsed Time
@ 250 VDC	@ 500 VDC	@ 750 VDC	@ 386° F
1.7×10^{10}	3.3×10^{10}	5.0×10^{10}	@ Ambient Temperature
2.5×10^7	2.8×10^7	2.8×10^7	~ 0 Hours
1.9×10^7	2.2×10^7	2.3×10^7	~ 4 Hours
3.9×10^7	3.8×10^7	3.6×10^7	~ 131 Hours
4.6×10^7	4.2×10^7	3.8×10^7	~ 161 Hours
3.7×10^7	3.6×10^7	3.1×10^7	~ 227 Hours

TABLE 11-11

CONDITION F AND F'

(Cϕ TO IRON F- Aϕ AND Bϕ SHORTED TO IRON, F'- Aϕ AND Bϕ SHORTED TO GROUND)

STATORETTE XI-1R AGC - ORGANIC INSULATION SYSTEM NITROGEN COVER GAS				
Insulation Resistance (Ω)			Gamma Dose (Rads)	Elapsed Time @ 386° F (Hours)
@ 250 VDC	@ 500 VDC	@ 750 VDC		
1.1×10^7	1.2×10^7	1.3×10^7	3.4×10^6	~ 7
3.5×10^6	3.1×10^6	2.9×10^6	2.4×10^7	~ 38
2.5×10^6	2.2×10^6	1.9×10^6	4.1×10^7	~ 59
*2.3×10^6	1.9×10^6	1.6×10^6	6.3×10^7	~ 90
*1.8×10^6	1.6×10^6	1.2×10^6	8.6×10^7	~174
*1.4×10^6	1.3×10^6	9.5×10^5	1.07×10^8	~211

STATORETTE XI-2R AGC - INORGANIC INSULATION SYSTEM CAPSULE EVACUATED				
Insulation Resistance (Ω)			Gamma Dose (Rads)	Elapsed Time @ 386° F (Hours)
@ 250 VDC	@ 500 VDC	@ 750 VDC		
4.0×10^8	4.2×10^8	4.0×10^8	3.3×10^6	~ 9
5.7×10^8	6.1×10^8	6.2×10^8	2.3×10^7	~ 38
7.4×10^8	8.2×10^8	7.8×10^8	4.0×10^7	~ 61
*2.1×10^9	1.9×10^9	1.7×10^9	6.2×10^7	~ 90
*2.5×10^9	2.6×10^9	2.3×10^9	8.4×10^7	~178
*2.5×10^9	2.5×10^9	2.3×10^9	1.04×10^8	~211

STATORETTE XI-3R GE - ORGANIC INSULATION SYSTEM WITH ET-378 IN CAPSULE				
Insulation Resistance (Ω)			Gamma Dose (Rads)	Elapsed Time @ 386° F (Hours)
@ 250 VDC	@ 500 VDC	@ 750 VDC		
6.2×10^7	6.1×10^7	6.2×10^7	3.3×10^6	~ 9
6.6×10^7	6.4×10^7	6.2×10^7	2.4×10^7	~ 39
7.1×10^7	7.2×10^7	6.8×10^7	4.0×10^7	~ 61
*8.9×10^7	8.6×10^7	7.5×10^7	6.2×10^7	~ 90
*8.6×10^7	8.6×10^7	7.7×10^7	8.4×10^7	~178
*7.8×10^7	7.8×10^7	7.5×10^7	1.04×10^8	~211

* F'

TABLE 11-12

CONDITION F'

(C ϕ TO IRON WITH A ϕ AND B ϕ SHORTED TO GROUND)

STATORETTE XI-1C AGC - ORGANIC INSULATION SYSTEM NITROGEN COVER GAS

Insulation Resistance (Ω)			Elapsed Time
@ 250 VDC	@ 500 VDC	@ 750 VDC	@ 386° F
4.9×10^9	1.8×10^9	1.6×10^9	@ Ambient Temperature
4.5×10^5	@ 475 VDC 4.5×10^5	-----	~ 0 Hours
4.6×10^5	5.0×10^5	-----	~ 3 Hours
4.6×10^5	5.0×10^5	-----	~ 8 Hours
3.1×10^5	@ 375 VDC 3.75×10^5	-----	~ 84 Hours
3.4×10^5	@ 340 VDC 3.4×10^5	-----	~ 204 Hours

STATORETTE XI-2C AGC - INORGANIC INSULATION SYSTEM CAPSULE EVACUATED

Insulation Resistance (Ω)			Elapsed Time
@250 VDC	@ 500 VDC	@ 750 VDC	@ 386° F
2.5×10^{13}	1.2×10^{13}	1.2×10^{13}	@ Ambient Temperature
3.0×10^{10}	2.1×10^{10}	1.8×10^{10}	~ 0 Hours
2.9×10^{10}	2.1×10^{10}	1.8×10^{10}	~ 3.5 Hours
2.7×10^{10}	2.1×10^{10}	1.8×10^{10}	~ 57 Hours
3.3×10^{10}	2.5×10^{10}	2.2×10^{10}	~ 84 Hours
3.9×10^{10}	2.8×10^{10}	2.3×10^{10}	~ 87 Hours

STATORETTE XI-3C GE - ORGANIC INSULATION SYSTEM WITH ET-378 IN CAPSULE

Insulation Resistance (Ω)			Elapsed Time
@250 VDC	@ 500 VDC	@ 750 VDC	@ 386° F
1.7×10^{10}	3.3×10^{10}	5.0×10^{10}	@ Ambient Temperature
2.3×10^7	2.4×10^7	2.3×10^7	~ 0 Hours
1.9×10^7	2.1×10^7	2.1×10^7	~ 4 Hours
4.4×10^7	4.2×10^7	4.0×10^7	~ 131 Hours
5.0×10^7	4.5×10^7	4.0×10^7	~ 161 Hours
3.7×10^7	3.3×10^7	3.0×10^7	~ 227 Hours

TABLE II-13

CAPACITANCE AND DISSIPATION FACTOR

RADIATION STATORETTE XI-1 AGC ORGANIC INSULATION SYSTEM - NITROGEN COVER GAS					
CONDITION				GAMMA DOSE (Rads)	ELAPSED TIME @ 386° F (Hours)
"A" PHASE TO "B" PHASE		"A" PHASE TO IRON			
CAPACITANCE (pF)	DISSIPATION FACTOR	CAPACITANCE (pF)	DISSIPATION FACTOR		
62.2100	0.00351	261.893	0.003978	*	---
85.4979	0.1293	328.986	0.1121	**	---
80.1480	0.2495	337.306	0.2063	5.1×10^6	~ 10
99.5380	0.4426	404.625	0.3482	2.6×10^7	~ 37
106.455	0.4857	421.296	0.3718	3.2×10^7	~ 46
124.404	0.5787	472.744	0.4380	4.3×10^7	~ 60
165.164	0.7392	574.714	0.5342	6.5×10^7	~ 90
236.400	0.9340	725.601	0.6219	7.9×10^7	~ 162
257.745	0.9654	768.655	0.6352	9.5×10^7	~ 186
297.	1.000	847.525	0.6624	1.08×10^8	~ 210

* Pre-Test @ Ambient Temperature

** Pre-Test @ 392° F

TABLE 11-14

CAPACITANCE AND DISSIPATION FACTOR

RADIATION STATORETTE XI-2 AGC INORGANIC INSULATION SYSTEM - CAPSULE EVACUATED					
CONDITION				GAMMA DOSE (Rads)	ELAPSED TIME @ 386° F (Hours)
"A" PHASE TO "B" PHASE		"A" PHASE TO IRON			
CAPACITANCE (pF)	DISSIPATION FACTOR	CAPACITANCE (pF)	DISSIPATION FACTOR		
50.1016	0.006631	237.267	0.01341	*	---
51.1221	0.01756	241.698	0.02759	**	---
54.1390	0.07460	249.590	0.06770	4.9×10^6	~ 10
53.0380	0.05064	245.829	0.05151	2.5×10^7	~ 37
52.7004	0.04537	244.939	0.04771	3.1×10^7	~ 46
52.6066	0.04313	244.435	0.0456	4.1×10^7	~ 60
52.3136	0.03883	243.716	0.04241	6.3×10^7	~ 88
52.0395	0.03440	242.585	0.03823	7.7×10^7	~ 156
51.9243	0.03273	242.322	0.03683	9.2×10^7	~ 183
51.8404	0.03190	242.150	0.03604	1.04×10^7	~ 210

* Pre-Test @ Ambient Temperature

** Pre-Test @ 392° F

TABLE 11-15

CAPACITANCE AND DISSIPATION FACTOR

CONTROL STATORETTE XI-2 AGC INORGANIC INSULATION SYSTEM - CAPSULE EVACUATED				
CONDITION				ELAPSED TIME @ 386° F (Hours)
"A" PHASE TO "B" PHASE		"A" PHASE TO IRON		
CAPACITANCE (pF)	DISSIPATION FACTOR	CAPACITANCE (pF)	DISSIPATION FACTOR	
149.495	0.01269	317.480	0.01238	@ Ambient Temperature
152.969	0.03314	320.278	0.03001	~ 2
152.938	0.03272	320.211	0.02664	~ 6
152.8	0.032	319.98	0.0262	~ 14
148.69	0.0315	319.7	0.0260	~ 60
152.57	0.0305	319.24	0.0246	~ 86
153.0	0.0279	319.62	0.0230	~ 108
152.601	0.02672	318.991	0.02271	~ 186
153.1	0.016	319.7	0.0166	~ 205
152.9	0.0219	319.3	0.0201	~ 228

TABLE 11-16

CAPACITANCE AND DISSIPATION FACTOR

RADIATION STATORETTE XI-3 GE ORGANIC INSULATION SYSTEM WITH ET-378 IN CAPSULE					
CONDITION				GAMMA DOSE (Rads)	ELAPSED TIME @ 386° F (Hours)
"A" PHASE TO "B" PHASE		"A" PHASE TO IRON			
CAPACITANCE (pF)	DISSIPATION FACTOR	CAPACITANCE (pF)	DISSIPATION FACTOR		
580.922	0.004614	2475.02	0.003458	*	--
612.589	0.003532	2591.86	0.009345	**	--
629.580	0.01002	2668.90	0.03152	4.9×10^6	~ 10
~ 406.	~ 0.0025	2533.16	0.0554	2.5×10^7	~ 37
~ 402.	~ 0.0066	2518.09	0.05234	3.1×10^7	~ 46
~ 400.	-----	2516.86	0.05810	4.1×10^7	~ 60
~ 400.	-----	2514.84	0.06310	6.3×10^7	~ 90
352.669	0.05560	2519.95	0.0715	7.7×10^7	~ 160
~ 213.6	~ 0.0002	2509.08	0.06569	8.4×10^7	~ 175
~ 588.09	0.07351	2519.46	0.07392	1.04×10^8	~ 210

* Pre-Test @ Ambient Temperature

** Pre-Test @ 392° F

TABLE 11-17
CAPACITANCE AND DISSIPATION FACTOR
CONTROL STATORETTE XI-3 GE ORGANIC INSULATION SYSTEM WITH ET-378 IN CAPSULE

CONDITION				ELAPSED TIME @ 386° F (Hours)
"A" PHASE TO "B" PHASE		"A" PHASE TO IRON		
CAPACITANCE (pF)	DISSIPATION FACTOR	CAPACITANCE (pF)	DISSIPATION FACTOR	
1428.78	0.00739	2800.00	0.00485	@ Ambient Temperature
1603.92	0.04846	3147.52	0.04625	~ 2
1577.11	0.04775	3097.47	0.04375	~ 7
1554.	0.0461	3054.	0.0428	~ 14
1538.3	0.0432	2986.61	0.03956	~ 60
1487.4	0.0417	2926.17	0.0386	~ 86
1476.06	0.0477	2903.33	0.04453	~108
1473.61	0.05051	2898.73	0.04764	~186
1472.56	0.05214	2898.55	0.04892	~205
1476.6	0.057	2905.5	0.054	~228

TABLE 11-18
CAPACITANCE AND DISSIPATION FACTOR - STATORETTES
POST-TEST REL - AMBIENT TEMPERATURE

SPECIMEN IDENTIFICATION	CONNECTION	CAPACITANCE (pF)		DISSIPATION FACTOR (%)	
		CONTROL STATORETTE	IRRADIATED STATORETTE	CONTROL STATORETTE	IRRADIATED STATORETTE
XI-1	A ϕ - B ϕ	219.704	144.604	0.1122	0.0036
	A ϕ - C ϕ	216.121	132.935	0.1070	0.0033
	B ϕ - C ϕ	192.023	147.586	0.0260	0.0035
	A ϕ - Iron	397.817	292.972	0.0874	0.0036
	B ϕ - Iron	417.278	284.636	0.0658	0.0052
	C ϕ - Iron	400.978	294.098	0.0470	0.0033
XI-2	A ϕ - B ϕ	150.370	135.331	0.0110	0.0120
	A ϕ - C ϕ	160.314	147.534	0.0085	0.0108
	B ϕ - C ϕ	173.273	154.597	0.0096	0.0120
	A ϕ - Iron	317.010	290.668	0.0103	0.0132
	B ϕ - Iron	318.946	299.847	0.0123	0.0142
	C ϕ - Iron	318.535	301.234	0.0113	0.0154
XI-3	A ϕ - B ϕ	1374.77	1308.39	0.0067	0.0045
	A ϕ - C ϕ	1343.96	1283.20	0.0049	0.0038
	B ϕ - C ϕ	1379.73	1326.33	0.0066	0.0041
	A ϕ - Iron	2701.73	2615.77	0.0045	0.0040
	B ϕ - Iron	2728.45	2658.85	0.0054	0.0041
	C ϕ - Iron	2715.81	2663.68	0.0045	0.0039

TABLE 11-19

DIELECTRIC BREAKDOWN VOLTAGE

MOTOR STATORETTES

STATORETTE TYPE	DIELECTRIC BREAKDOWN VOLTAGE VAC - RMS	
	CONTROL	IRRADIATED
XI-1 AGC Organic Insulation System - Nitrogen Cover Gas	3,200	3,460
XI-2 AGC Inorganic Insulation System - Capsule Evacuated	3,700	1,000 - 1,200
XI-3 GE Organic Insulation System With ET-378 Fluid in Capsule	2,800	2,600

12.0 TEST SPECIMENS

GROUP XII TEFLON SHEET AND COATING

XII-1 Teflon film, DuPont Co.

XII-2 Teflon coated steel specimen, DuPont Co.

12.1 PROCEDURE

The capsule containing samples of the Teflon sheet and the bonded Teflon coating was filled with approximately 20 ml VI-1 organic fluid, then heated at 180° F for four (4) hours at a pressure of $<$ 1 mm Hg., purged with Helium, and then sealed under vacuum.

After irradiation, isopropyl alcohol was used to remove the ET-378 fluid. The weight change was determined as per ND5001 (Rev. 27 April 1964) paragraph 4.2.4.

Tensile elongation specimens were cut using an ASTM die (1/4 inch width), and all specimens were failed in the Scott Tester and elongation measurements were made (See Section 4.2 and Table 4.1 of ND 5001 (Rev. 27 April 1964)).

Wetting was determined by placing a drop of ET-378 fluid on the Teflon coating, a picture was made, and a tangent drawn at the point of contact of the oil drop and the surface of the coating. The subtended angle was measured and recorded.

12.2 NUCLEAR ENVIRONMENT

	NEUTRON FLUX		GAMMA DOSE	
	Rate	Integrated	Rate	Integrated
Material	$n/cm^2/sec$	n/cm	Rads/Hr.	Rads
1	9.2×10^7	4.6×10^{13}	7.5×10^5	1.0×10^8
2	9.2×10^7	4.6×10^{13}	7.5×10^5	1.0×10^8

12.3 RESULTS

The irradiated Teflon sheet showed a color change from transparent white to a light brown.

12.3.2 Elongation

12.3.2.1 XIII-1 Material

There was a reduction of 82 percent in percent elongation due to radiation and temperature (See Table 12-1).

12.3.3 Change in Contact Angle of ET-378 Oil and Teflon Coating Surface.

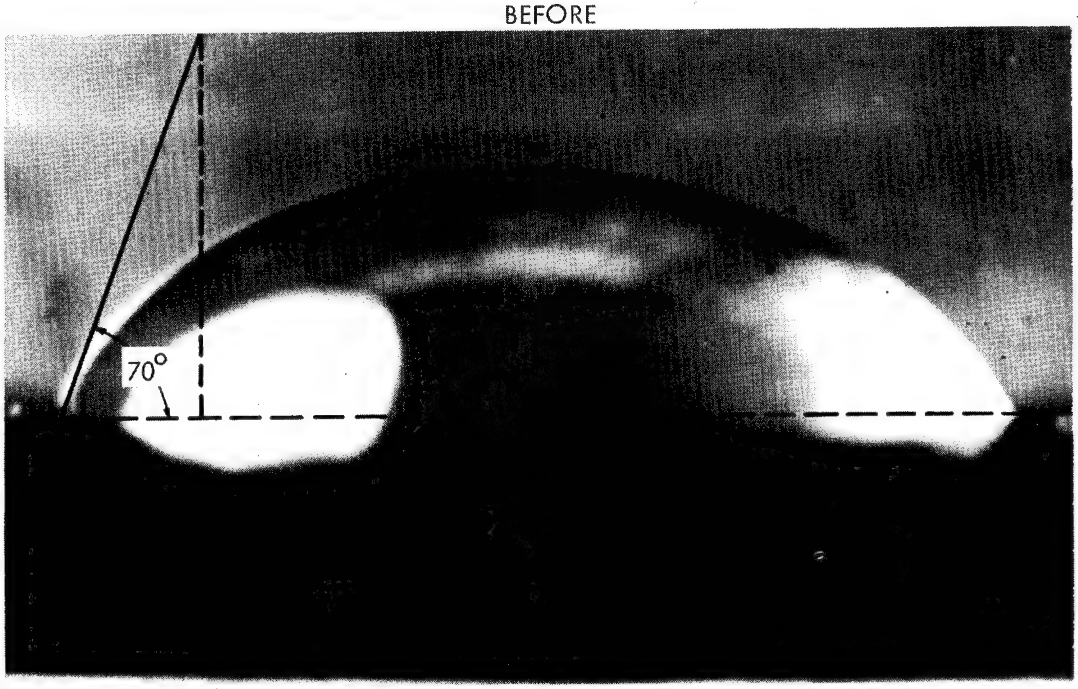
12.3.3.1 XII-2 Material

There was approximately a 29 percent decrease in the contract angle between the Teflon coating and ET-378 oil between the pre- and post-irradiation tests. (See Table 12-1 and Figure 12-1).

12.3.4 Weight Change

All test specimens showed a slight increase ($< \pm$ 1%) in weight. (See Table 12-1)

BEFORE



AFTER

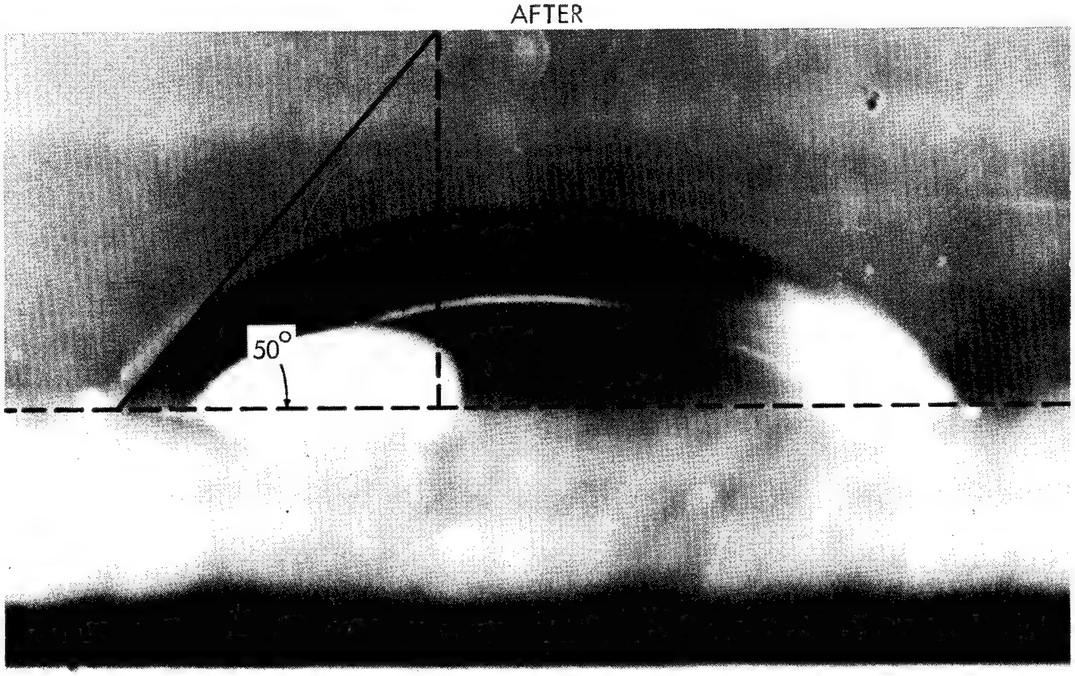


FIGURE 12-1 CONTACT ANGLE BETWEEN TEFLON COATED SPECIMEN AND DROP OF ET-378 OIL BEFORE AND AFTER IRRADIATION

TABLE 12-1

WEIGHT CHANGE, ELONGATION AND WETTING

XII-1 AND 2

Material And Specimen Number	WEIGHT				PERCENT ELONGATION		CONTACT ANGLE	
	GRAMS		CHANGE					
	Before Exposure	After Exposure	Grams	Percent	Value	Percent Change	Degree	Percent Change
1-A1	—	—	—	—	156	—	—	—
1-R13	0.4442	0.4470	+0.0028	+0.6	29	-83	—	—
1-R14	—	—	—	—	26	—	—	—
2-A1	—	—	—	—	—	—	~70°	—
2-R13	39.4948	39.5147	+0.0199	+0.5	—	—	~50°	~-29

13.0 NUCLEAR MEASUREMENTS FOR AEROJET TEST NO. 1

GENERAL

To obtain thorough knowledge of the gamma-ray dose rate and the fast neutron flux in the volumes to be occupied by Aerojet test articles, neutron and gamma maps were taken behind the LiH shield during preliminary reactor runs. A framework consisted of curved 1/8 inch thick aluminum front and back plates to simulate the test environmental chambers. The radius of curvature was the same as that of the LiH shield. The framework was mounted on the front of a test car permitting positioning within 1/4 inch of the LiH shield. On each of the small aluminum rods connecting the front and back plates a dosimeter bracket was attached to hold both neutron and gamma dosimeters. The brackets could be positioned at any point along the rod; thus permitting any dosimeter to LiH shield distance from 1/2 inch to 14 inches without moving the framework.

13.1 GAMMA MAPPING

A gamma dose rate map, using dosimeters, was made at a dosimeter to shield distance of 5.5 inches both with LiH and with LiH plus 8 inches water shielding. An additional map was made at a dosimeter to shield distance of 18 inches with LiH plus 8 inches water. These measurements were made with aluminum and carbon electrode, CO_2 filled, 4 cc ionization chambers and read with a Keithley Model 410 micromicroammeter. Each dosimeter was calibrated in a gamma field produced by a 660 curie Co^{60} source prior to use at the RER. The Co^{60} gamma field was measured with an NBS calibrated Victoreen "R" meter.

In addition to the above measurements, a 15 point map was made with chemical dosimeters obtained from and read by Edgerton, Germeshausen, and Grier, Inc. This map was made at a dosimeter - LiH distance of 5.5 inches with LiH plus 8 inches water.

All reactor operations for gamma dose rate mapping were at a power level of 1 megawatt. All gamma dose rates are given in rads/hr. which were converted from r/hr. by division by 0.877. Dose rates obtained with 4 cc ionization chambers are estimated to be accurate to $\pm$ 10%.

During each gamma dose rate mapping experiment, two 4 cc ionization chambers were used as monitors at a location remote from the mapping volume to facilitate dose rate normalization and for dose accumulation data during the test irradiations, since dosimeters could not be operated at the temperature of the environmental chamber.

Gamma dose rate mapping results are shown in Figures 13-1, 13-2, and 13-3.

13.2 NEUTRON MAPPING

A complete 19 dosimeter fast neutron flux map was made at dosimeter to LiH distances of 2.5 inches, 6.5 inches, and 10.5 inches with the LiH shield in place. This map was performed with nickel foils utilizing the Ni^{58} (n, p) Co^{58} reaction (E_T =5.0 MeV). Foil counting was performed on the GNL automatic counting system and data reduction was accomplished on the Lockheed IBM 7090 digital computer. These data are presented in Figures 13-4, 13-5, and 13-6.

In addition to the fast neutron flux map described above, a fast neutron spectrum measurement was made with a set of foils located at the framework center and 2.5 inches from the LiH shield. The set consisted of foils as follows:

$S^{32}(n,p)\,P^{32}$	E_T = 2.9 MeV;	σ_E = .300 barns
$Ni^{58}(n,p)\,Co^{58}$	E_T = 5.0 MeV;	σ_E = 1.23 barns
$Mg^{24}(n,p)\,Na^{24}$	E_T = 6.3 MeV;	σ_E = 0.048 barns
$Al^{27}(n,\alpha)\,Na^{24}$	E_T = 8.1 MeV;	σ_E = 0.110 barns

Fission foils were not used because of the severe photofission interference problem. The fast neutron spectrum obtained as described above is presented in Figure 13-7. As seen in Figure 7, with LiH only, the conversion from the 5.0 MeV integral flux to the 0.1 MeV integral flux is a factor of 6. (Previous data taken at GNL, 8 inches of water show the conversion factor to be 18.9.)

During test article irradiation, the integrated fast neutron flux was measured on each test article panel with nickel foils. Neutron data are estimated to be accurate to $\pm$ 50%.

RADIATION MONITORING FOR TEST NO. 1

The two gamma dose rate monitors which were located outside the test enclosure as described under gamma mapping were read continuously during Test 1; thus, providing the reactor cycle history. The monitor dose rate to test article dose rate ratio was determined during gamma mapping. Applying this ratio to the dose rate monitor readings and summing over the entire reactor cycle history the total exposure dose to the test articles was obtained. That is:

$$D = \sum_{i=0}^{i=17} a R_i T_i, \text{ where}$$

a = Monitor to test article dose rate ratio.
R_i = Monitor dose rate during $i^{\underline{th}}$ power cycle.
T_i = Duration of the $i^{\underline{th}}$ power cycle.

The total gamma dose received at the center of the test panel is given in Table 13-1. The total dose received at other points can be derived using the dose rate distribution in Figure 13-1.

The integrated fast neutron flux was obtained by placing a nickel foil at each of 22 locations on the test panel for the duration of the test. Foils were counted and the normal data reduction techniques utilizing the reactor cycle history provided fast neutron integrated flux results. These data are presented in Figure 13-8.

Figure 13-9 shows the reactor power cycle history for Aerojet Test No. 1.

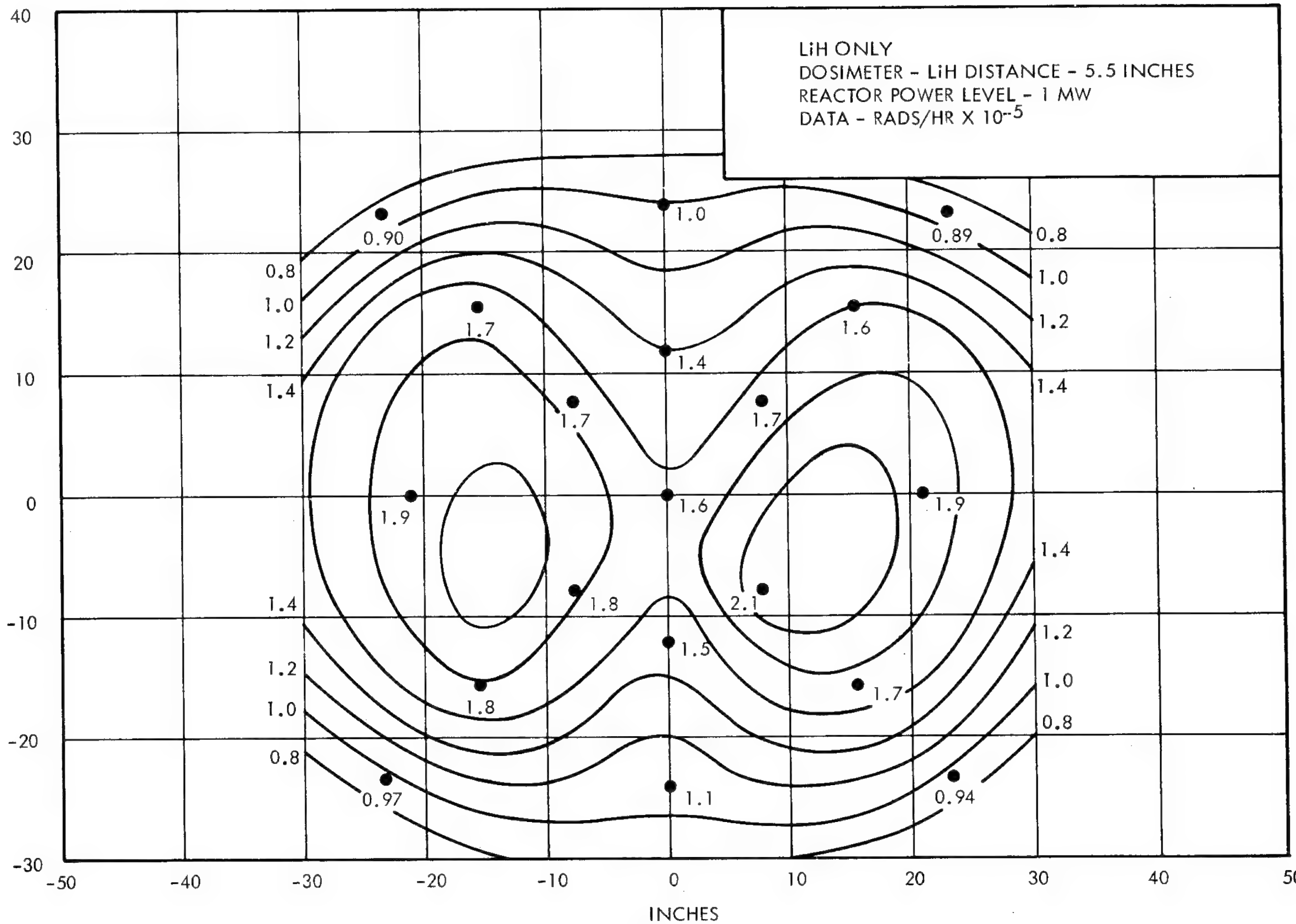


FIGURE 13-1 GAMMA DOSE RATE MAP (VIEW FROM REACTOR)

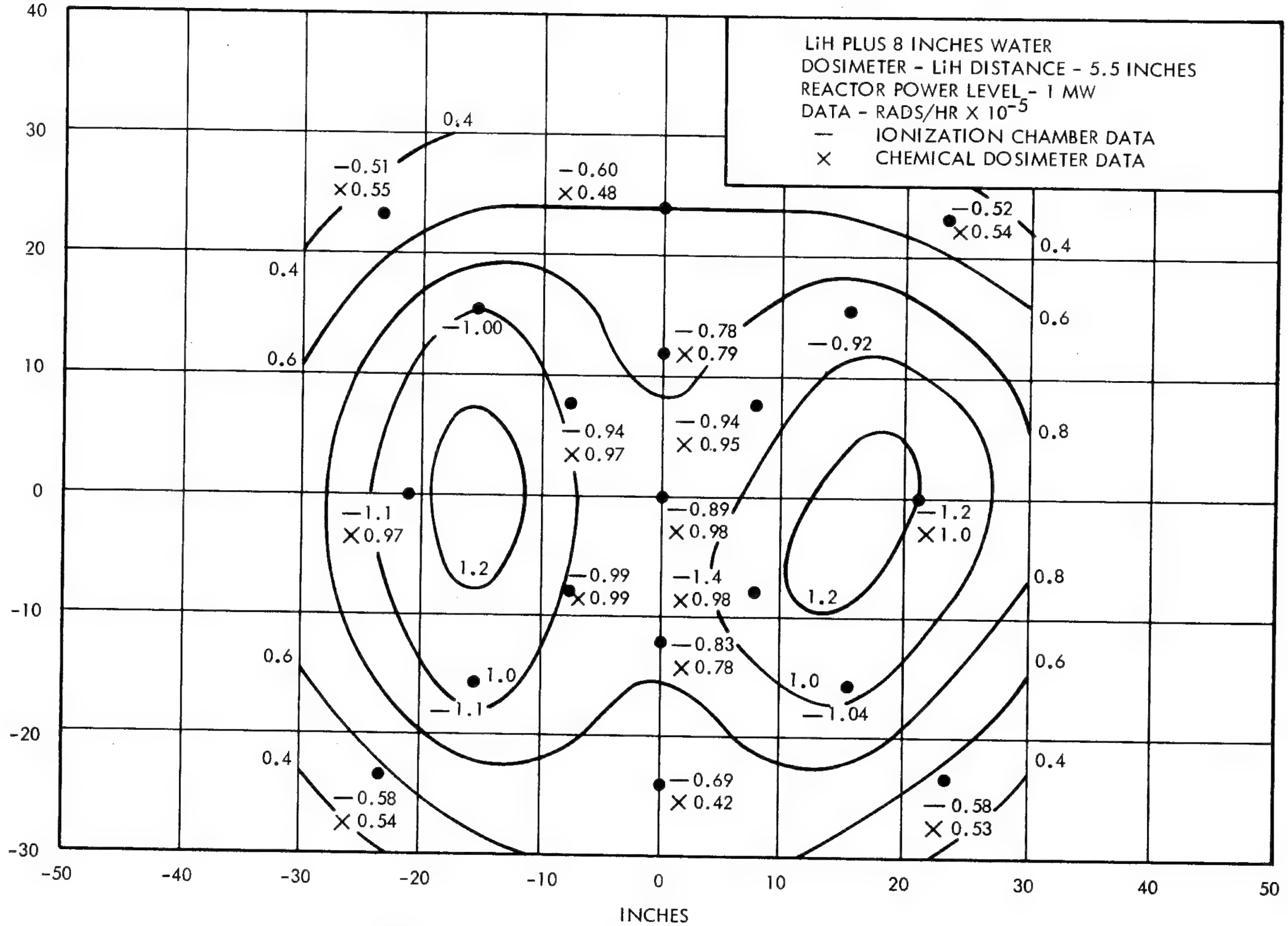


FIGURE 13-2 GAMMA DOSE RATE MAP (VIEW FROM REACTOR)

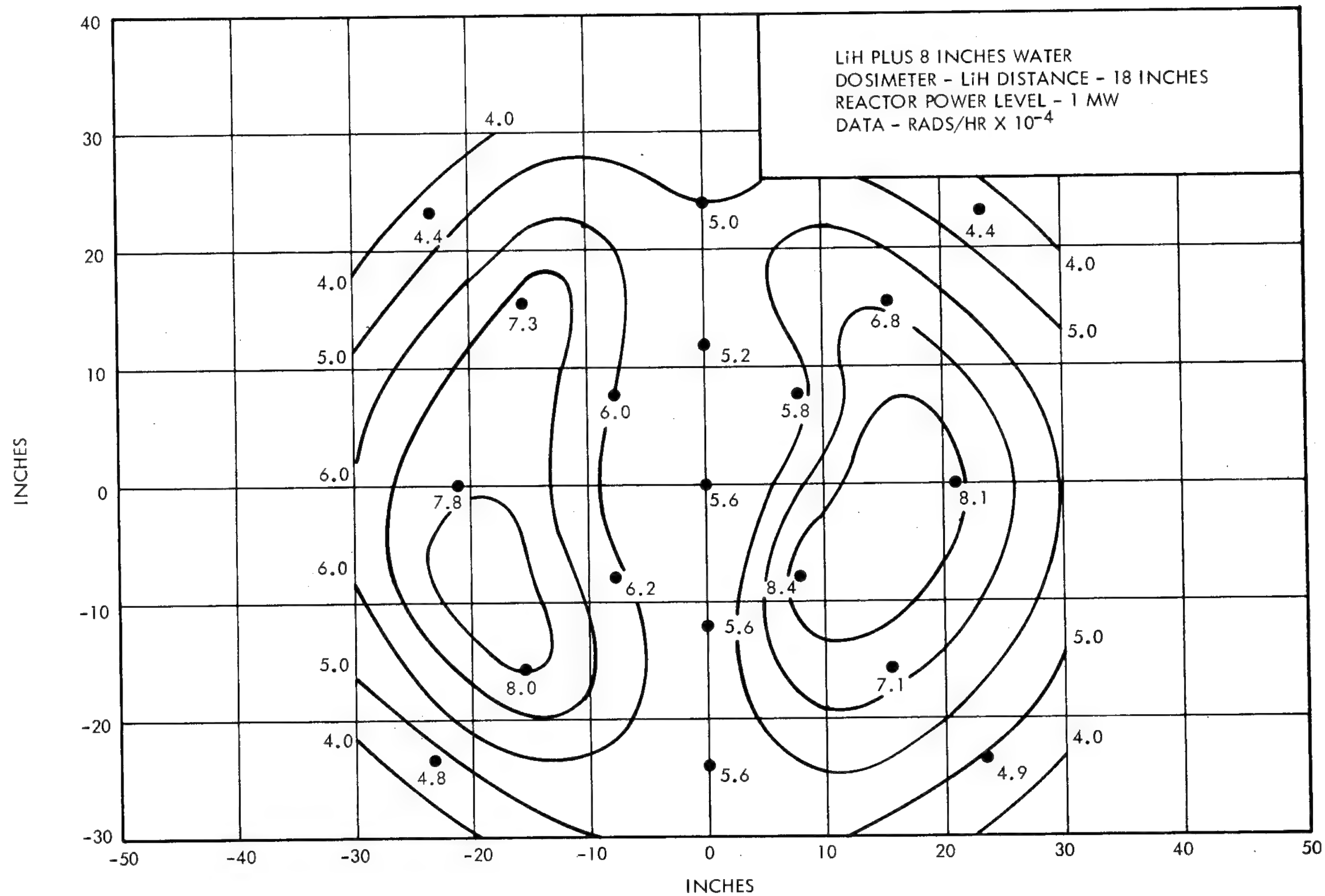


FIGURE 13-3 GAMMA DOSE RATE MAP (VIEW FROM REACTOR)

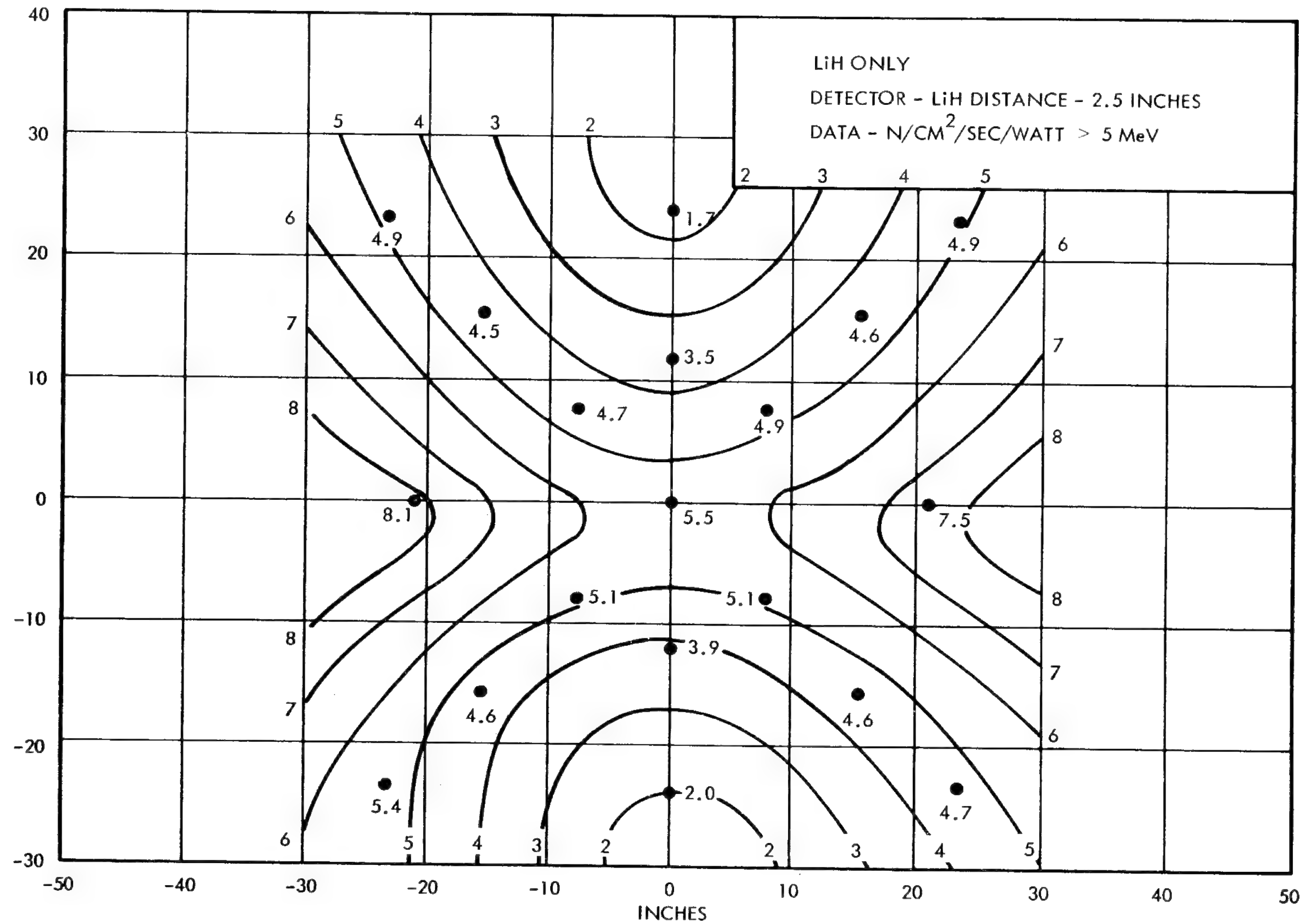


FIGURE 13-4 FAST NEUTRON FLUX MAP (VIEW FROM REACTOR)

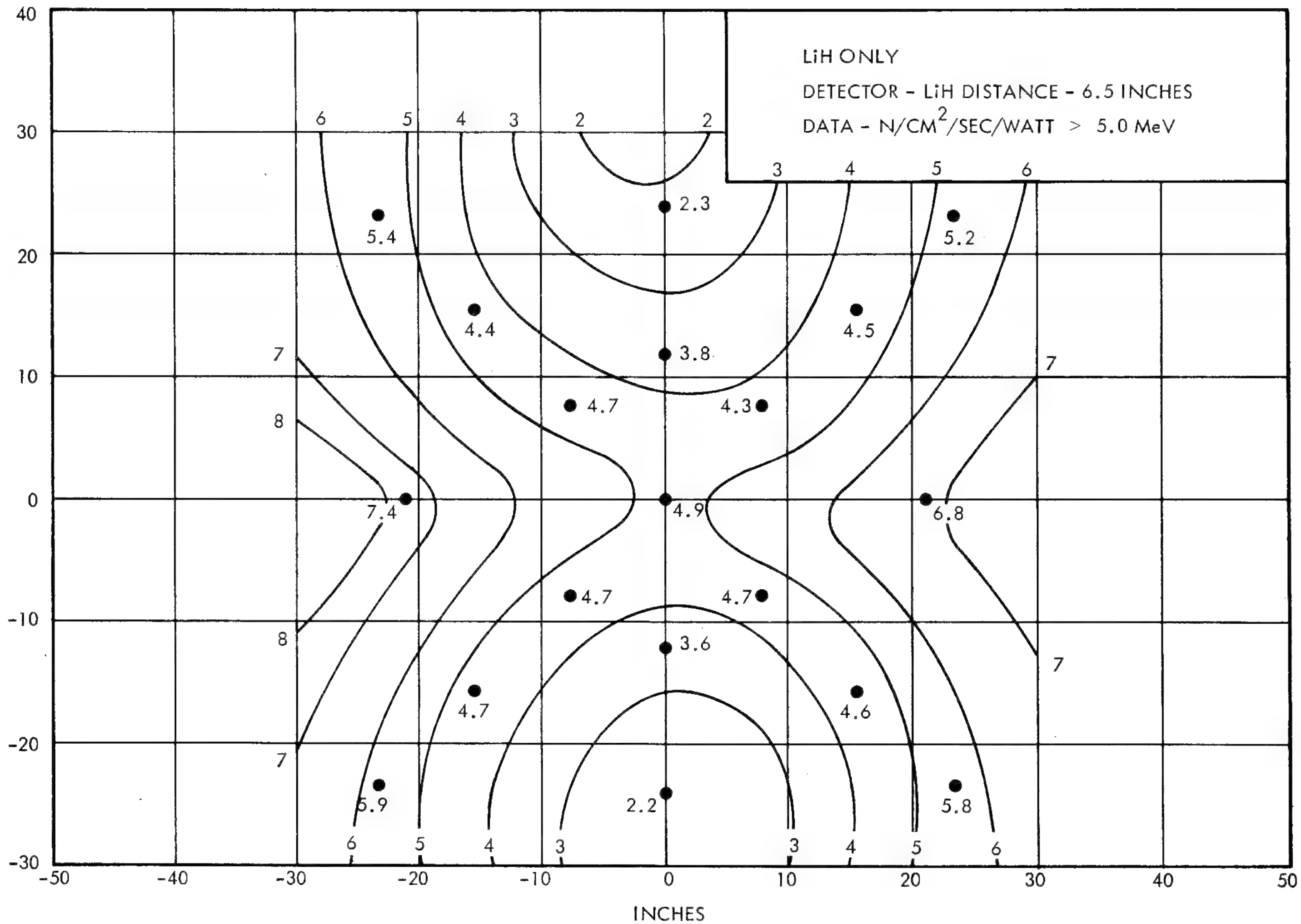


FIGURE 13-5 FAST NEUTRON FLUX MAP (VIEW FROM REACTOR)

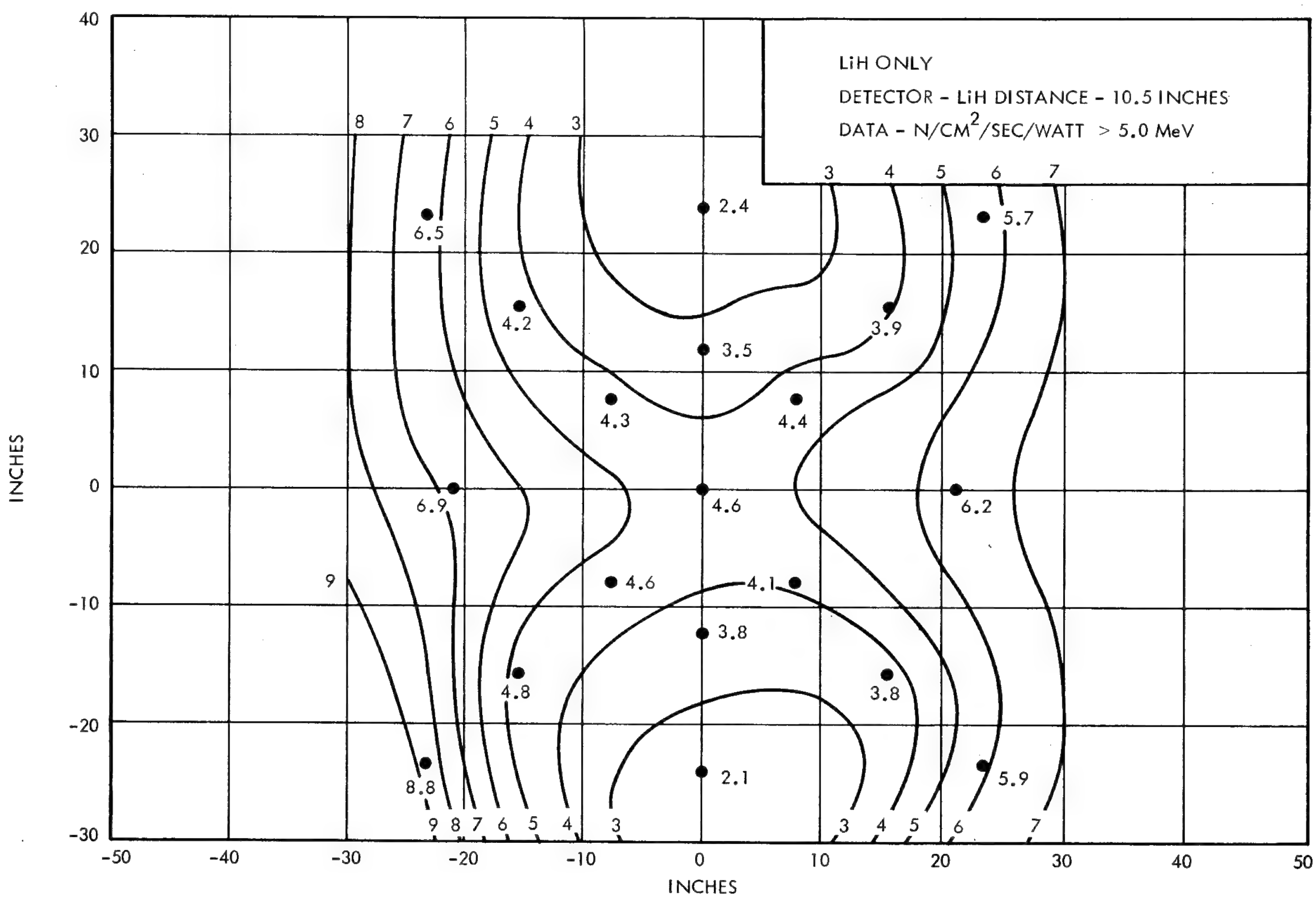


FIGURE 13-6 FAST NEUTRON FLUX MAP (VIEW FROM REACTOR)

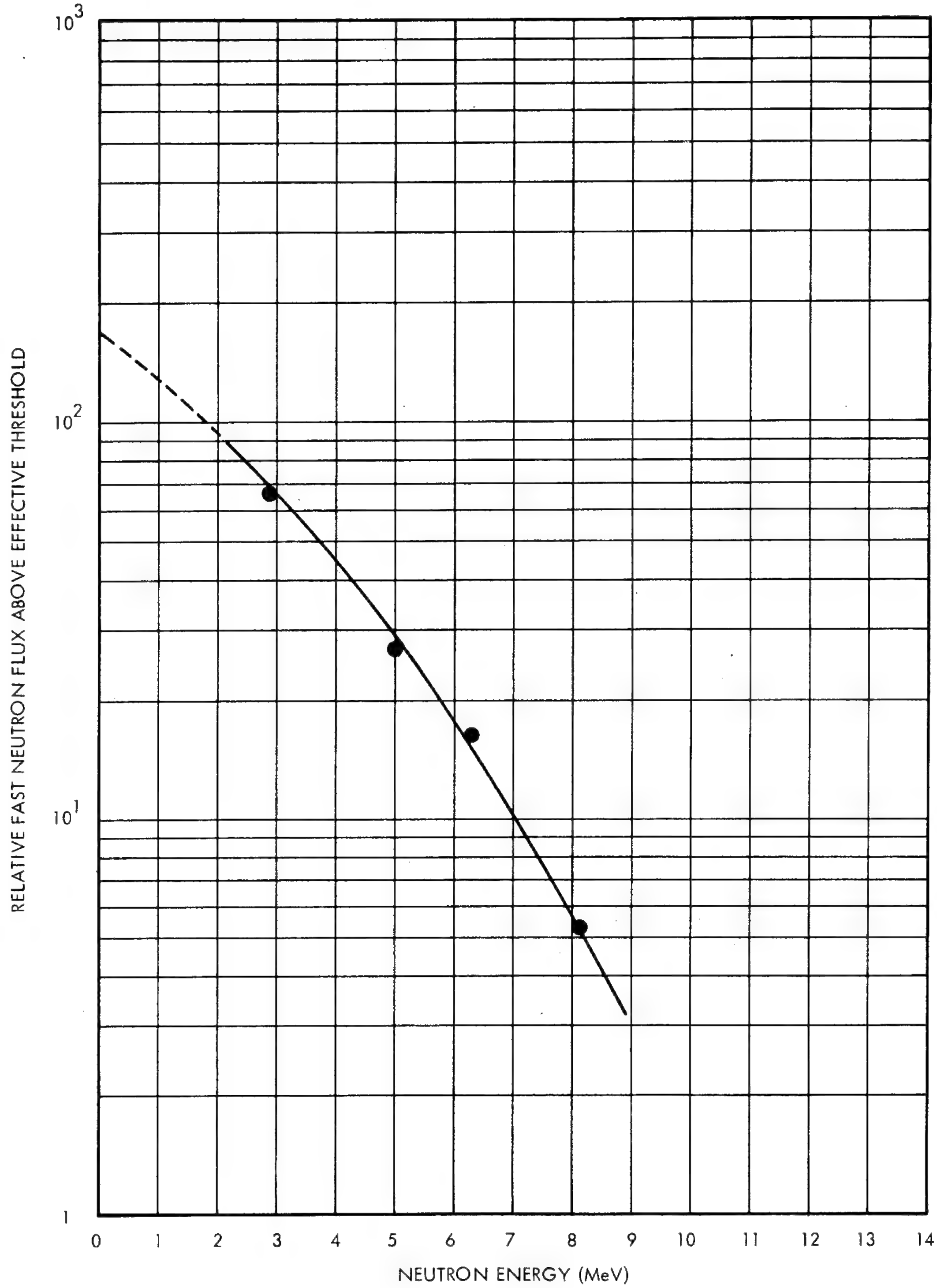


FIGURE 13-7 FAST NEUTRON SPECTRUM

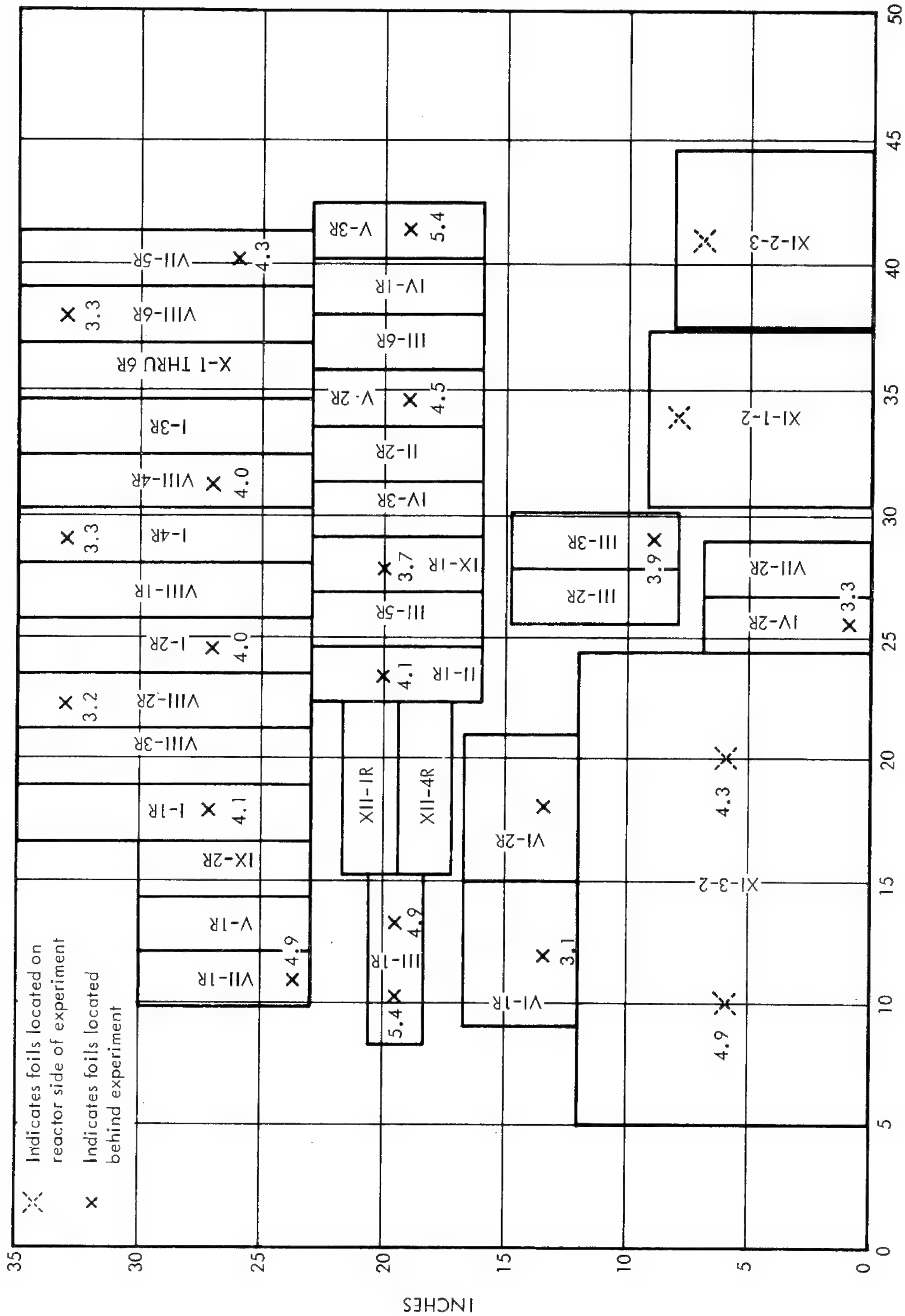


FIGURE 13-8 AEROJET TEST NO. 1 - NEUTRON DATA INTEGRATED FLUX > 0.1 MeV FOR ENTIRE TEST X 10^{-13}

VIEW FROM REACTOR

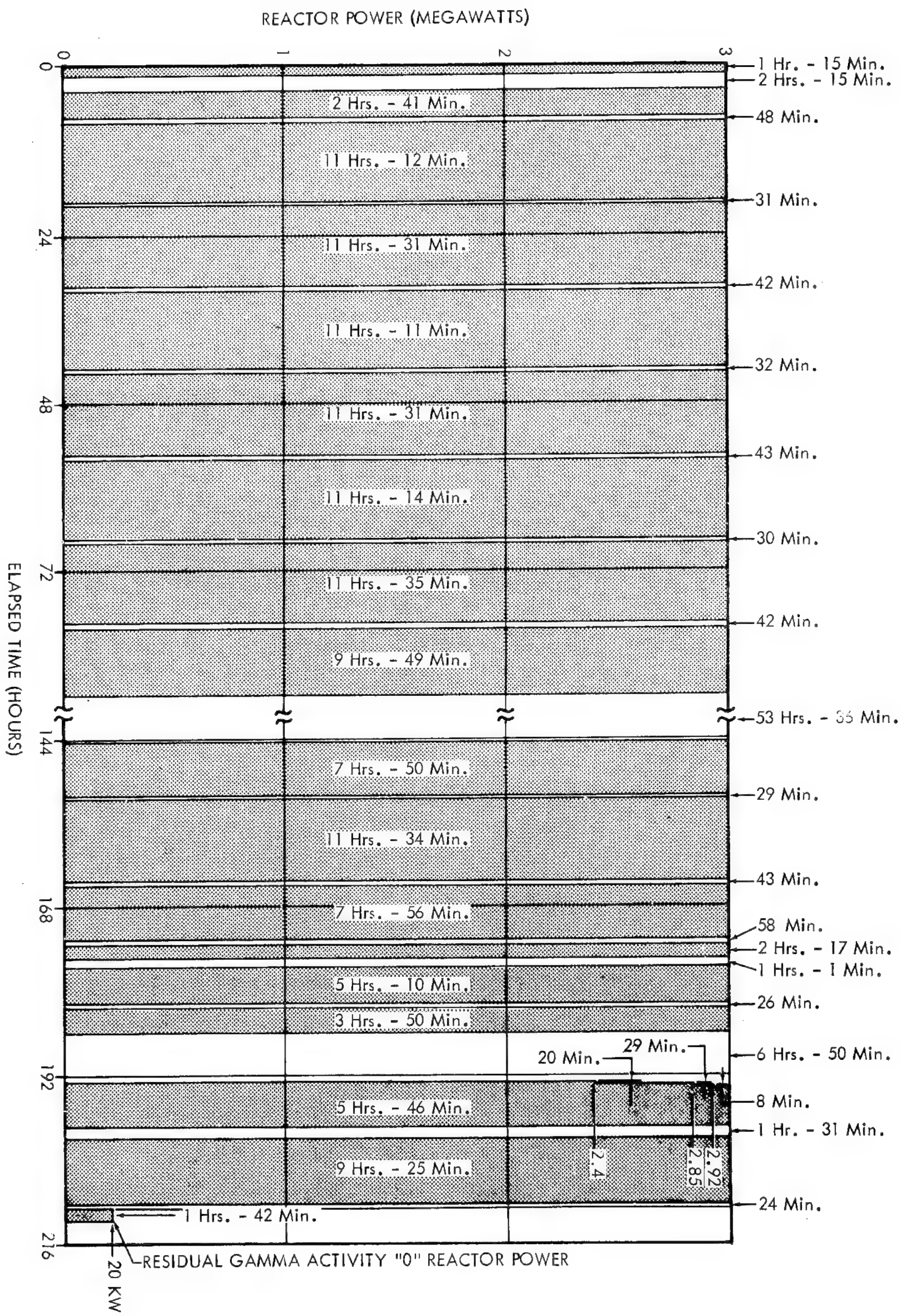


FIGURE 13-9 REACTOR HISTORY

TABLE 13-1

AEROJET TEST NO. 1

(INSULATION MATERIALS)

GAMMA DATA

Position: Vertical and Horizontal Center of Test Oven
3 inches from LiH

Dose Rate at 3 MW: 7.0×10^5 Rads/Hr.

Dose/MW Hr.: 2.3×10^5 Rads

Dose for Entire Test: 1.1×10^8 R = 9.6×10^7 Rads (Center)

$\frac{N/cm^2}{Rad}$ (at Test Center) : 4.1×10^5

ADDENDUM
January 1965

STATORETTE TEMPERATURE CYCLE

An additional temperature test was performed on the X1-1 statorettes (Aerojet Genera - Organic Insulation System) to better define their temperature insulation resistance characteristics. Insulation resistance measurements were made at ambient temperature and at periodic intervals as the temperature was increased to approximately 200°C, allowed to stabilize and decreased to ambient.

After completion of the above test the irradiated statorette was dissected to observe the insulation around the inner conductors. The results are tabulated in Tables A-1 and A-2.

STATORETTE LEAK CHECK

The statorette capsules were leak checked at the completion of all tests. The fill tubes were cut off to permit leak checking the capsule. The fill tubes themselves were also checked. With the exception of statorettes X1-1R and X1-1C no leaks greater than the original leak specification were detected.

The leaks found on the Group X1-1 statorettes were around terminal connections. These leaks could have been caused when the terminals were heated during the process of making connection to the oven lead wires for the second temperature cycle.

TABLE A-1 INSULATION RESISTANCE VS TEMPERATURE X1-1C STATORETTE

Insulation Resistance (Ohms)				Temp. °C	Elapsed Time (Hours)
Aφ - Iron	Cφ- Iron	Aφ - Bφ	Aφ - Cφ		
4.2×10^{10}	2.6×10^{10}	3.1×10^{10}	3.0×10^{10}	23.5	0
2.8×10^{10}	2.1×10^{10}			24.5	
		2.0×10^{10}	1.7×10^{10}	25.5	
2.0×10^{9}	2.7×10^{9}			30.0	
		1.8×10^{10}	8.9×10^{9}	34.0	
5.9×10^{8}	6.3×10^{8}			44.0	0.78
		2.6×10^{9}	6.3×10^{8}	48.5	
1.5×10^{8}	1.0×10^{8}			64.0	
		3.3×10^{8}	1.6×10^{8}	70.0	
2.5×10^{7}	1.8×10^{7}			86.0	
		6.8×10^{7}	4.8×10^{7}	91.5	
5.7×10^{6}	5.0×10^{6}			105.0	1.62
		2.2×10^{7}	1.8×10^{7}	110.0	
2.4×10^{6}	2.3×10^{6}			122.5	2.05
		9.6×10^{6}	8.6×10^{6}	127.5	
1.4×10^{6}	1.4×10^{6}			-	
		6.6×10^{6}	6.1×10^{6}	142.0	
1.1×10^{6}	1.2×10^{6}			152.0	2.48
		-	5.2×10^{6}	154.5	
1.0×10^{6}	1.1×10^{6}			159.5	2.73
		5.4×10^{6}	5.4×10^{6}	162.0	
1.1×10^{6}	1.2×10^{6}			167.0	3.00
		6.3×10^{6}	6.2×10^{6}	169.0	
1.4×10^{6}	1.4×10^{6}			175.0	3.40
		7.7×10^{6}	7.4×10^{6}	177.0	
1.6×10^{6}	1.6×10^{6}			178.5	

TABLE A-1 INSULATION RESISTANCE VS TEMPERATURE X1-1C STATORETTE
(Continued)

Insulation Resistance (Ohms)				Temp. °C	Elapsed Time (Hours)
Aφ- Iron	Cφ - Iron	Aφ - Bφ	Aφ - Cφ		
		8.2×10^6	7.8×10^6	179.0	
1.8×10^6	1.8×10^6			181.0	3.77
		8.5×10^6	8.2×10^6	181.5	
1.9×10^6	1.8×10^6			183.0	4.40
		8.5×10^6	8.1×10^6	184.0	
2.0×10^6	1.8×10^6			185.0	
		8.2×10^6	7.9×10^6	185.5	
1.9×10^6	1.7×10^6			186.0	
		7.6×10^6	7.5×10^6	186.5	
1.5×10^6	1.4×10^6	5.8×10^6	6.0×10^6	189.0	6.22
1.6×10^6	1.5×10^6	5.8×10^6	5.9×10^6	189.5	
1.6×10^6	1.4×10^6	5.6×10^6	5.8×10^6	190.0	7.00
1.0×10^6	1.0×10^6			190.5	23.10
		4.8×10^6	5.0×10^6	191.0	
1.1×10^6	1.0×10^6			190.5	25.00
		5.1×10^6	5.4×10^6	190.5	
1.3×10^6	1.2×10^6	5.5×10^6	6.2×10^6	190.5	0*
4.5×10^6	3.8×10^6			183.0	
		1.9×10^7	2.2×10^7	181.0	0.43
9.4×10^6	8.2×10^6			175.5	
		4.2×10^7	4.0×10^7	173.0	0.65
2.1×10^{11}	2.0×10^{11}	2.3×10^{11}	2.3×10^{11}	23.5	68.50

* Start of cool down.

TABLE A-2 INSULATION RESISTANCE VS TEMPERATURE X1-1R STATORETTE

Insulation Resistance (Ohms)			Temp. °C	Elapsed Time (Hours)
$A\varphi$ - Iron	$C\varphi$ - Iron	$A\varphi$ - $C\varphi$		
5.9×10^{10}	2.3×10^{10}	3.3×10^{12}	23.5	0
1.4×10^{10}	1.5×10^{10}		27.0	
		1.9×10^{12}	30.0	
1.3×10^{10}	1.0×10^{10}		38.5	
		1.3×10^{11}	40.0	
4.5×10^{9}	4.5×10^{9}		55.0	0.87
		1.1×10^{11}	62.0	
2.9×10^{9}	3.1×10^{9}		77.5	
		6.7×10^{10}	81.0	
2.1×10^{9}	2.2×10^{9}		100.0	1.50
		3.8×10^{10}	103.0	
1.3×10^{9}	1.4×10^{9}		119.0	1.77
		1.4×10^{10}	121.0	
7.1×10^{8}	7.9×10^{8}		137.5	
		4.5×10^{9}	140.5	
3.8×10^{8}	3.8×10^{8}		153.0	2.37
		2.9×10^{9}	155.0	
3.3×10^{8}	3.1×10^{8}		161.5	2.60
		2.5×10^{9}	163.0	
2.8×10^{8}	2.6×10^{8}		169.0	2.87
		2.3×10^{9}	170.0	
2.7×10^{8}	2.5×10^{8}		175.5	3.13
		2.2×10^{9}	176.0	
2.9×10^{8}	2.6×10^{8}		181.5	
		2.1×10^{9}	182.0	
3.0×10^{8}	2.7×10^{8}		183.5	

TABLE A-2 INSULATION RESISTANCE VS TEMPERATURE X1-1R STATORETTE
(Continued)

Insulation Resistance (Ohms)			Temp. °C	Elapsed Time (Hours)
$A\varphi$ - Iron	$C\varphi$ - Iron	$A\varphi$ - $C\varphi$		
		2.1×10^9	184.0	
3.0×10^8	2.8×10^8		185.5	4.06
		2.1×10^9	186.0	
3.1×10^8	2.8×10^8		187.0	4.37
		2.1×10^9	187.5	
3.0×10^8	2.8×10^8		188.0	
		2.0×10^9	188.5	
3.2×10^8	3.1×10^8	2.0×10^9	189.0	5.00
3.0×10^8	2.6×10^8	1.4×10^9	190.5	
2.9×10^8	2.5×10^8	1.3×10^9	190.5	
2.1×10^8	2.1×10^8	9.8×10^8	190.5	7.00
9.8×10^6	9.3×10^6	6.4×10^7	191.0	23.10
9.8×10^6	9.3×10^6	6.4×10^7	191.0	25.00
1.3×10^7	1.5×10^7		189.5	0 *
		1.2×10^8	189.0	
7.4×10^7	8.2×10^7		185.0	
		5.1×10^8	184.0	
1.3×10^9	5.0×10^9		178.0	
		2.6×10^9	176.0	0.35
4.5×10^9	4.5×10^9		124.0	
		4.0×10^{10}	123.5	3.62
8.5×10^{11}	1.0×10^{12}	1.2×10^{13}	23.5	68.50

* Start of cool down.

VISUAL EXAMINATION OF INSULATION SYSTEM X1-1R
AEROJET GENERAL STATORETTE

The visual examination of the X1-1R statorette shows a definite and heavy powdering of the insulation around the inner conductors. The insulation appeared to have been poorly cured. The powdering appeared to be throughout the statorette winding and not just in isolated areas.

The prior history of this statorette after receipt from Aerojet General is as follows:

1. Conditioning and encapsulation as per Experimental Design Manual.
2. Irradiation plus elevated temperature (approx. $200^{o}C$) for approximately 200 hours with an irradiation exposure of 1.09×10^{8} Rads and 4.0×10^{13} nvt.
3. Post-irradiation temperature cycle to approximate $200^{o}C$.